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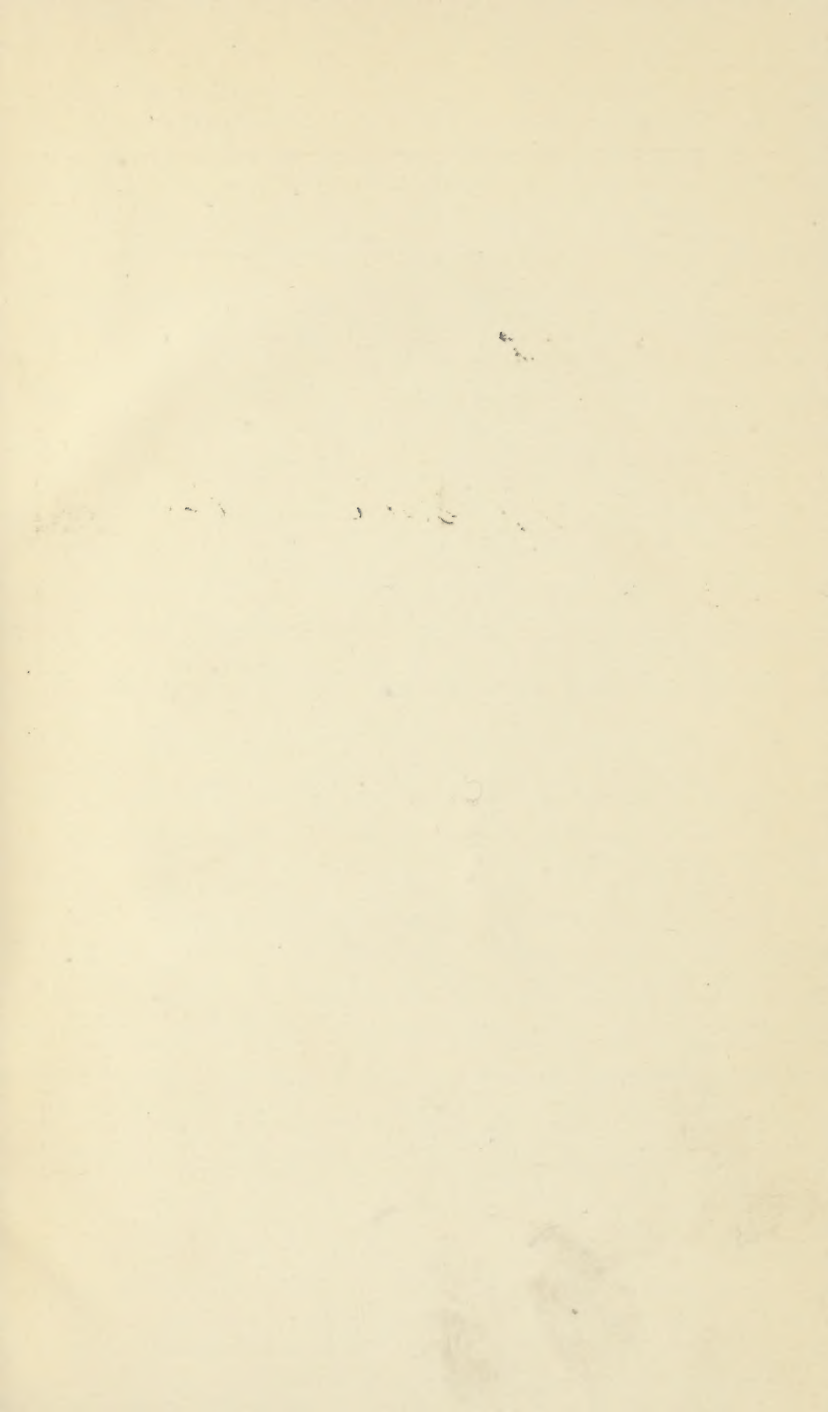
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ARRANGED IN SIXTEEN VOLUMES
WITH A HISTORY OF SCIENCE, GLOSSARIES
AND A GENERAL INDEX

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VOLUME TEN

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NEW YORK

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MEDICINE

THE SCIENCE OF HEALTH

BY

WILFRED M. BARTON

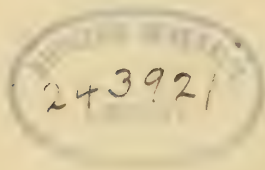
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PREFACE

MEDICINE is an ancient art, since some of the Egyptian medical papyri date back as far as four thousand years B. C. The difficulty therefore of condensing into a narrow space the principal facts and figures of medical history so that the reader may get a clear idea of the subject will readily be appreciated. But inasmuch as an understanding of the gradual development of medical science from superstition, myth, and fable to its present high estate is necessary to a comprehensive grasp of the subject, the author has devoted the first portion of the book to an historical review. It is hoped that his efforts in this direction have been performed in such a manner as to give a real interest as well as a cultural value to this part of the work.

Modern medicine is a highly developed science and art, whose chief aim at present is prophylaxis or prevention of disease. It is for this reason that the historical portion of the book is followed by articles which describe the great epidemics and plagues of the world and their conquest by modern medicine, and the great medical foundations, such as the Rockefeller Institute and others, which are devoted to medical research and to preventive medicine. Naturally the important part which medicine played in the great world war, recently concluded, comes in for a share of attention. The terrible suffering of the war could scarcely have been borne

by mankind without the amelioration brought about by medical science.

Finally a book which attempts to give the reader a comprehensive idea of just what constitutes the solidarity and the greatness of medical science must treat of the problems of disease itself, which next to death is the archenemy of man. The second portion of the book, therefore, deals with diseases, their manifold causes and phenomena, their recognition and their treatment. This part of the book is in no sense intended to be a treatise on the domestic handling of disease. On the contrary the author has made it plain that this function must properly be left to the physician, upon whose learned judgment and knowledge the responsibility must and should always rest.

In conclusion the author desires to express his appreciation to Dr. Clarence Ransom and Dr. John M. Ladd for their indefatigable assistance in many phases of the work, and to Col. Fielding H. Garrison, U. S. A., assistant librarian of the Surgeon General's library, for help in the selection of illustrations and many valuable suggestions.

WILFRED M. BARTON.

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PART I

CHAPTER I

ANCIENT MEDICINE—EGYPTIAN, GRECIAN, ROMAN, ARABIAN

THE oldest, if not the strongest, instinct of life in all its forms is that of self-preservation. The world has been populated for countless ages with a flora and fauna, each species and individual of which has been instinctively, or by virtue of conscious reasoning, devoting much of its span of life simply toward maintaining the primitive functions of what we term life. This great dominating instinct may be recognized in a multitude of varieties of its original form. A noted psychologist has coined the term "herd-instinct," and has pointed to the indisputable fact that, so far as the human race is concerned, the tendency to form groups, as a defensive, and later as a constructive phenomenon, has been a profound factor in our specific evolution. The instinct of selection of food, and the simple defensive reactions to factors which endanger life, such as shelter, flight, and hiding, and aggressive means to combat destructive enemies, may be cited as examples of the fundamental fact that all life is deeply concerned in its preservation.

The evolution of so-called higher forms of life has naturally brought about a complication and an

elaboration of these primal instincts. It sufficed for early man to stay in his cave, or beneath the protection of the foliage of his mighty trees to avoid exposure to dangerous storms, or to enemies in bodily form. It sufficed to gather his food when the need required and the opportunity permitted, though he probably went hungry for long periods before he evolved the habit of reversing the order of these activities. Obedience to a few instincts assured him that under ordinary circumstances he would continue to live, and that was his great problem. But slowly, through the ages, has grown in him the concept that he could do more than live. He has diversified his interests, broadened his activities, and varied his methods of expression, and has concluded that he is entitled, to use the famous phrase of our fathers, to liberty and the pursuit of happiness, in addition to a claim for mere existence. One of the countless natural products of his wider evolution has been the development of a science of medicine, which, in all its phases, is but the expression in a much modified cultural form of the instinct of the preservation of life and its normal functions. It is the purpose of this work to trace something of the history of the development of this science, with its background of profound instinctive coloring; to describe at length its achievements, and to denote its status and its significance among the sciences of to-day.

The evolution of medicine, or the development of its history, may be viewed from several angles. First might be observed the development of medicine as a profession. In such a record would of necessity occur the description of its cultural and social relations at various epochs of its history.

Again, since in this, as in all historic subjects, we are dependent entirely upon a series of written records for our information of what occurred beyond the yesterday of our existence, the historian might approach it from the standpoint of medical literature, and merely present the chronological table of such contributions. Finally, it may be considered in the light of a doctrine, and since constantly there have been tireless workers giving of their efforts, brilliant minds of their genius, and brave men of their lives, in order that as a science it might occupy its present dignified and commanding place, it is fitting that we should consider the history of medicine as the history of a doctrine.

It is a remarkable fact that the earliest records of things medical lead us to assume beyond peradventure the existence of medicine as an established doctrine in Egypt, at least 4,500 years before Christ. At this time there lived the first physician of whom we have definite record. He was called I-em-hetep (He who cometh in peace), enjoyed a position of influence during the dynasty of that period, and was subsequently honored by the erection of a temple in his name, and deification. It naturally follows that we cannot know the real beginning of medicine. We cannot know the manner of man who stepped aside from his instinctive path of self-living to commit the first act of healing, which, though possibly tinged with crudity, ignorance, or superstition, was, nevertheless, the potential origin of the greatest conserving science of the human race.

Prehistoric medicine, naturally, is largely a matter of conjecture, but it seems logical to assume that it was chiefly in the hands of the "herb doctor,"

the midwife, and the priest. F. H. Garrison, in his delightful and accurate volume on the "History of Medicine," to which this work is chiefly indebted for much of its detail, ascribes with concise logic the psychotherapy, the treatment with incantations, spells, and utterly useless herbs, of diseases which in the mind of primitive man were caused by bad spirits, or other supernatural agencies, to the unity or solidarity of folklore, and proves the proposition that "primitive medicine is inseparable from primitive modes of religious belief." This concept holds true even after we enter the historic period of medicine. The early records of Egyptian medicine show that the therapy of the period was hopelessly futile, and that it was founded on superstition and folklore. The concoction composed by the three witches of Macbeth is brought to mind in reading of the haphazard mixtures of these ancients, one of which, containing the "fats of the lion, hippopotamus, crocodile, goose, serpent, and ibex," was considered of great efficacy in the treatment of baldness. The papyri discovered by Ebers at Thebes, said to have been written about 1550 B. C., describes at some length certain diseases of the period, difficult of recognition in modern terms, and gives a summary of drugs, herbs, and remedies of the time. Many actual chemical compounds were known and used, such as antimony, copper sulphate, and bicarbonate of soda, but from their use, and similar usage of vegetable and even animal extracts, it must be concluded that too often patients recovered "in spite of the physician."

Early Oriental medicine, particularly of the Babylonian and Jewish periods, deserve especial attention, notably that of the latter. Much has been

said of various dynasties of the Chinese Empire concerning the remarkable advance this race made in chemistry, engineering, art, and medicine. A tendency has grown up in modern times to view China as a country where once a splendid cultural development flourished, and to invest the prehistoric Chinese with various virtues of knowledge and skill surpassing even those of our day. Some authors would have us believe that this country, like some huge hibernating animal, once possessed a civilization of tremendously advanced proportions, exercised faculties of culture and learning not arrived at by modern nations, and now has retired in its winter of life, burying its secrets with it, and waits for the first sun of new impetus to waken from its lethargy of ages, to show again to the eyes of the world its former glory.

This much may be safely said: Records, up to and including the periods we are now considering, show that these Asiatics contributed practically nothing in written form of value to the doctrine of medicine. Their knowledge and skill at a sort of homeopathic massage has been recognized and acknowledged, but their therapy, and particularly their systems of anatomy and pathology have been described as *sinnlos* jumble whose outstanding quality was their massivity.

The Hindus of the period between 1500 B. C. and 1000 A. D. contributed a peculiarly valuable mass of information on medical subjects, especially in the branch of operative surgery. They were probably the first users of an anesthetic, and the well known drug *Cannabis indica* (Indian hemp) was the chief vehicle of their progress in this important direction. Without antiseptic or aseptic technique they per-

formed practically all of the types of major surgical operations now known. Abdominal incisions for hernia, Cæsarian section (it is well to note here that this operation is by many supposed to have been named after one of the Cæsars of the Roman Empire), and the removal of tumors were made, and their surgical instruments were well constructed and of distinctly useful types. We are inclined to view with no little pride and conceit our surgery of to-day, as a thing of modern beauty; but, owing to the factor of pain to the patient, it is not at all unlikely that the ancient Hindu surgeon was fully as deft, and of necessity a more rapid operator. Indeed, it has been said that "we have improved on ancient Hindu surgery in only three regards—ligation of vessels for the control of hemorrhage; general anesthesia, permitting operative leisure, and asepsis, guaranteeing freedom from infection," and it is significant that these three things, hemorrhage, pain, and infection, perplexed surgeons for the following twelve centuries.

Early Babylonian medicine, obeying the doctrine of the solidarity of folklore, was in the hands of the priesthood, and in this period a special relation existed between disease and its treatment, and astrology, that offshoot of astronomy, which was to prove the greatest impediment to progress in medicine it has encountered. However, it is interesting to note that as early as 2200 B. C. there existed a definite profession of medicine under legislative control. Stipulated fees were charged by the "astrologer-priest-physician," and curiously enough he was held strictly accountable for accidents or deaths occurring in his practice, and was at times punished severely by the code governing these

matters. Garrison tells us that according to the Code of Hammurabi the physician was not so severely punished when the accident happened to a slave, as when it happened to a gentleman or freeman. In the latter case a sort of policy existed which reminds us of the lines of the song from the "Mikado"—"let the punishment fit the crime." In the case of the freeman, if an accident happened which caused the patient to lose his sight, the physician stood liable to lose his hand!

We may well consider here the history of medicine among the early Jews. Many historians deservedly give high credit to the Jewish race for the perfection of its hygienic laws, enumerated with such severity in Exodus, Leviticus, and Numbers in the Bible. The early Jews also practiced circumcision, used the obstetric chair, and devoted no little effort toward the eradication of "unclean" diseases of mind and body, and observed a rest or Sabbath day once in seven. The effect of the old Mosaic laws cannot be too greatly stressed. They were destined to affect the world for ages to come, and were altogether the most important contribution from the standpoint of preventive medicine the world has received until comparatively recent times. Again it was the priests who "on the eighth day" circumcised the male children; and in Leviticus xiii, we read:

"When a man shall have in the skin of his flesh a rising, a scab, or bright spot, and it be in the skin of his flesh like the plague of leprosy; then shall he be brought unto Aaron the priest, or unto one of his sons the priests;

"And the priest shall look on the plague of the flesh: and when the hair in the plague is turned white, and the plague is in sight, but deeper than

the skin of his flesh, it is a plague of leprosy: and the priest shall look at him, and pronounce him unclean."

Aside from fragmentary bits of history, all of which evidenced this apparently inseparable correlation of medicine and religion, we must wait until Homer (about 950 B. C.) to hear of the beginning of the organization of medicine in the hands of individuals who were not priests, and to hear of its natural expansion and elaboration in countries whose cultural and intellectual resources were greater.

It is true that Homeric medicine is intimately associated with Greek mythology and in that sense with religion and the priests, but we learn that this state of affairs was soon changed, culminating in the appearance and work of Hippocrates, whom many call the "Father of Medicine." To the early Greek mind Apollo was the original god of healing, as is typical of the elaboration of mythology; his place was later taken by his son Asclepius or Æsculapius. Æthiopis of Archinus first tells us of this Æsculapius, son of Apollo by a nymph, as being especially trained in medicine and surgery.

He had two daughters, Panacea and Hygeia, whose names will be recognized among nomenclatural roots of to-day, and two sons, Machaon and Podalirius, both of whom are repeatedly mentioned in the Iliad. Of Machaon it was said "he could heal injuries," but Podalirius earned the signal tribute of being said to have the "gift of recognizing what was not visible to the naked eye, and the duty of tending what could not be healed." Some historians have cited this as the beginning of the separation

of the physician and surgeon as units in the field of medicine. Aside from Homeric mention of these men, we know nothing, but their father, after his alleged death by a thunderbolt from Olympus, because of the complaint of Pluto that Hades was being depleted of new shades, had numerous temples erected in his honor, and his name is constantly associated to-day with the art for which he lived and died.

An interesting bit of record from these times comes in the form of tablets erected by appreciative patients on the walls of these temples. The patient repaired to the temple with his complaint and an offering, usually a ram for the latter. He was regaled by the priests with tales of the great prowess of the temple god, and the votive sacrifice was made. The patient then slept on the skin of the sacrificed animal and, dependent upon his ability to doze, the proper medical advice was either given in person by the physician of the temple, or learned from the dreams of the patient by interpretation. If the patient recovered, he was by custom bound to have the tablet inscribed and placed on the wall of the temple, giving the history of the ailment, the treatment, and the result. According to some this custom may have been the origin of the masterly description of diseases handed down to us from the age of Pericles by Hippocrates.

There was no essential change in the history of Grecian medicine until the time of Pythagoras of Samos (580-489 B. C.). Here is possibly the first instance of the true separation of the physician and the priest. Pythagoras was a philosopher who founded the Italian School at Crotona, but aside from the fact that medicine was beginning to assume

its own form as a science, and that Pythagoras exemplifies that fact, little need be said. His teachings and writings were clouded with a curious mysticism of numbers, and various complicated formulæ in which juggling of the four "elements," or elemental qualities, hot, dry, moist, and cold, produced symptomatic disease.

With the dawn of the Golden Age in Greece came the real foundation of medicine as a doctrinal entity. The broad fundamental principles on which its synthetic and deductive activities of to-day are based were established in the age of Pericles, and with few exceptions were the product of the brilliant observations and studies of one man—Hippocrates of Cos. Born in 460 B. C., claiming descent from Æsculapius, this eminent scholar traveled widely, especially through his own land, obtaining some instruction from his father, finally founding a school at Cos, where he instituted the practices and principles which to-day are universally recognized to be the most perfect of their kind, and some of which have remained practically unchanged. Much doubt has been thrown on the actual authorship of many writings ascribed to Hippocrates, but those mentioned here are certainly characteristic enough to be described as Hippocratic and for our purposes represent the value of the period and the man to historical medicine.

The first grand characteristic of Hippocratic medicine was the establishment of a code of ethical principles, lofty in ideal and regarded as the highest conception of the obligations of a physician. These were summed up in the famous "Oath of Hippocrates," which may well be reproduced here, exemplifying as it does, complete freedom from the

mystic imagery and superstition of priestcraft, and the vulgar pretension of a mercenary cult.

THE OATH

I swear by Apollo the physician, and Æsculapius, and Health, and Allheal, and all the gods and goddesses, that, according to my ability and judgment, I will keep this Oath and this stipulation—to reckon him who taught me this art equally dear to me as my parents, to share my substance with him, and relieve his necessities if required;

To look upon his offspring in the same footing as my own brothers, and to teach them this art, if they shall wish to learn it, without fee or stipulation; and that by precept, lecture, and every other mode of instruction, I will impart a knowledge of the art to my own sons, and those of my teachers, and to disciples bound by a stipulation and oath according to the law of medicine, but to none others.

I will follow that system of regimen which, according to my ability and judgment, I consider for the benefit of my patients, and abstain from whatever is deleterious and mischievous.

I will give no deadly medicine to anyone if asked, nor suggest any such counsel; and in like manner I will not give to a woman a pessary to produce abortion.

With purity and holiness, I will pass my life and practice my art.

I will not cut persons laboring under the stone, but will leave this to be done by men who are practitioners of this work.

Into whatever houses I enter, I will go into them for the benefit of the sick, and will abstain from every voluntary act of mischief and corruption; and, further, from the seduction of females or males, of freemen and slaves.

Whatever, in connection with my professional practice, or not in connection with it, I see or hear, in the life of men, which ought not to be spoken of abroad, I will not divulge, as reckoning that all such should be kept secret.

While I continue to keep this Oath unviolated, may it be granted to me to enjoy life and the practice of the art, respected by all men, in all times. But should I trespass and violate this Oath, may the reverse be my lot.

But by all odds the most valuable contribution of Hippocrates and the Hippocratic school was the singular artistry in the recognition of what might be called the laws of disease. Here, for the first time, physicians used their eyes and ears in the observation of the natural course of pathologic conditions. Symptoms and changes of symptoms were observed and recorded with the greatest nicety. Hippocrates so far approached free thinking as to doubt most strenuously the idea of the supernatural cause of disease, which, after all, was the one great step necessary for ancient man to take. He recognized that diseases tend to run a definite, essentially typical course, and that by the study of this course and its symptoms a disease could be named. He it was who established the point, now uniformly granted and applied in the best of our modern clinics, that the place to understand disease was at the bedside of the patient with the disease.

It is a brave thing to attempt, and, still more, a difficult thing to succeed in establishing a radical departure from existing lines of thought. All the bravery and success of the Golden Age in Greece reflects to the honor of that notable band of contemporaries, the equal of which probably never lived. Pericles, Plato, Aristophanes, Phidias, Sophocles, Herodotus, and their disciples and students form a group of wise men, learned scholars, and arbiters of the thoughts and acts of a rugged democracy, and among them it was altogether fitting that there should grow the first great physician, who, indeed, has been held by some to be the greatest of all physicians.

It must not be assumed that the science of medicine was already perfect in the Hippocratic period.

Dogma and theory still held their pernicious hold on the thought of the times, and in fact the very theory of disease held by Hippocrates and the school of Cos shows anything but accurate thought. The body was thought to contain four humors—blood, phlegm, black bile, and yellow bile, a correct relation of the existence of which was held to constitute health, and an improper proportion or wrong distribution was believed to be the cause of disease. This is called the “Humoral Doctrine,” and even up to the time of Harvey modified the thought and literature of medical schools of the world.

However, another decidedly valuable product of this period is the doctrine of “healing by natural processes.” Hippocrates has been wrongly reproached with teaching that nature alone suffices for the cure of disease. His own words are that it is the duty of the physician to “assist, or not to hinder” the natural course of “humoral” change, so that “the sick man might conquer the disease with the help of the physician.” This course of the humors was first “crude,” then passing through “coction” (or digestion) and finally being expelled by “crisis” (or resolution) through one of the eliminative channels of the organism. This brings to our attention one of the outstanding features of the Hippocratic system—that of the prognosis of the “crises” or periods of resolution of disease. The greatest care was exercised in the observation of the course of the disease, and it was considered of the highest importance to be able to forecast with certainty the day of “crisis.”

In treatment, this school attached but little importance to drugs, but minute attention was given to diet, ventilation, and active and passive motion of

affected parts. Two hundred and sixty drugs were mentioned in the Hippocratic writings, but their use was not well understood and still less called upon. As has been said, the treatment was chiefly hygienic, and it is at this time that we first see a sane, wholesome attitude toward the relation of physician and patient.

Active repudiation of Hippocrates and his Coan school was rare during the Grecian supremacy, but, as with his brilliant contemporaries, his reign was brief (although he was by some alleged to have died at 102 years) and he lacked a fitting successor. His approach to freedom of thought was absent in his followers, and it was not long before dogma and formalism wove their destructive way into the fabric of scientific medicine. Almost without exception, the valuable part of Hippocratic work, the theoretical, was gradually minimized, and the least valuable, the practical, was made prominent. In his masterly original essay on the phenomenon of the circulation of the blood, many years later, Harvey reminds us that the ideas of Hippocrates, and later Galen, held up to his time, and that the greatest difficulty of his (Harvey's) work was to maintain successful opposition to the ideas of these men whose supremacy had lived so long after them. Hippocrates has been variously called the "Father of Medicine," the "Great Physician," the "Healer of Cos"—all tributes to a man who stands alone among the physicians of the ages in point of genius.

Another important school enjoyed some prominence at this time—that of Cnidus. The essential difference in theory between the schools of Cos and Cnidus lay chiefly in their use of drugs. The latter school made a far more pretentious use of the com-

moner and well-known therapeutic compounds, the knowledge of many of which was probably imported from Egypt. A treatise on the diseases of women, contained in most of the translations of the Hippocratic writings, and of considerable practical value, has been attributed to this school.

Associated with the period, but following the times of Hippocrates, there appears another great scientific name, that of the philosopher, naturalist, and amateur physician, Aristotle. He was an ardent follower of the precepts of Plato, and his chief impress is that on the Alexandrian school. It is a singular fact that for a hundred years after the death of Hippocrates almost nothing was added to medical annals.

Eventually, however, and due largely to the dispersion of Greek science, art, and intellectual supremacy throughout the world following the conquests of Alexander the Great, various centers of medical learning which were fostered by more or less worthy successors of Hippocrates appeared in Greece, and more notably in Egypt. Among the latter was that of the famous Alexandrian school. Foremost among the men connected with the activities of this school, which ultimately effaced most of the minor scientific centers, stand Herophilus and Erasistratus. The former was a Greek, born in Chalcedon, and a product of the school of Cos, and was placed by many second only to the great founder of the Coan doctrine, of which he was a faithful disciple. His contemporary and rival, Erasistratus, instead of accepting the humoral theory of Hippocrates, espoused the cause of a mechanical explanation of disease, and actively opposed the Hippocratic ideas. Both of these great

men of Alexandria were anatomists of no mean degree, and their dissection represents the first of any real value to the medical world because of the important fact that it represented study of the human body itself, the subjects being usually criminals, who had undergone the death punishment.

Followers of Erasistratus, while contributing less of anatomic knowledge to the meager supply of the period than did the students of Herophilus, nevertheless paved the way for a very important doctrine—the empiric. This was possibly the most characteristic contribution of Alexandrian medicine. No name is now associated with the empiric doctrine, but its chief features were the rejection of the study of anatomy, as being unnecessary, and the almost exclusive use in their medical practice of the so-called “tripod of empiricism”—observation, history, and judgment by analogy.

While not an essentially important period in the history of the development of pure medical doctrine, still it is conceded that some few scientific contributions of the Alexandrian school were of sound value and permanent. The soundest was undoubtedly that of anatomic dissection. The trachea (windpipe), various minute bones (of the hand and foot), the gross anatomy of the intestinal tract, the prostate gland, and the heart were accurately described, and while their physiological functions were by no means understood, their mere description marked the beginning in a crude way of the exact study of the great objective background of the doctrine of medicine—the human body. Surgery and obstetrics received their proportionate impetus from a better understanding of the organs and

tissues involved, and despite the erratic tangent of thought pursued by the Erasistrateans, drug therapy and the teachings of Hippocrates did not fall into disrepute.

When Greece came under the domination of the Roman Empire after the downfall of Corinth (146 B. C.), Rome acted as a loadstone to Grecian physicians, and so superior were the Greeks in science that it may well be said that the Romans at no time originated or carried a school of medicine of their own. The Roman mind was not given to scientific rumination, and as a consequence practically all of the work of any value, even of peninsular origin, was at root Greek. Before the advent of the early Grecian pioneer physicians to Rome, Pliny tells us that for six hundred years there was no man of Roman origin whose profession could be dignified by the term physician. This is possibly stretching the facts a bit, but certainly so far as history records there were no medical writings of any consequence before the arrival in 218 B. C. of the Greek Archagathus. Many historians call attention to the dislike of the Romans to the itinerant Greek physicians, "despising them as mercenaries for accepting compensation for their services and otherwise distrusting them as possible poisoners and assassins."

On this account tribute must be paid to the medical skill and oratorical power of Asclepiades, a friend of Cicero, who came to Rome about 100 B. C. He naively introduced a doctrine of his own (solidism), founded on Epicurean principles, but conforming closely to the Stoic doctrine, thereby engaging the attention and acceptance of the better class of Romans. According to this diplomatic

physician, who opposed the humoral theory of Hippocrates, disease depended upon the alteration in size, shape, and relation of "atoms," of which, according to Epicurus, the body was composed. In the treatment of pathologic conditions, however, this astute man wisely reverted to the teachings of the school of Cos, and depended chiefly upon air, diet, external use of cold and warm water, and active and passive motion.

Some of his pupils further complicated matters by evolving from the principles of their master the doctrine of "methodism," wherein the "atoms" of Epicurus were found to possess one of three "qualities"—relaxation, constriction, or an indefinite mixed state, partly lax and partly tightened. Naturally, treatment was directed toward establishing a "method" of readjusting the tension of these atoms. The description of these methods gave the school its name. Subsequently this doctrine received an able champion in Soranus of Ephesus. Spoken of in praise even by the haughty Romans, this man contributed a work on the diseases of women which still exists in the Greek original, and which shows a truly remarkable insight into that subject. Still another theory appeared in the first century A. D. to befog the atmosphere of Greco-Roman medicine—the "pneumatic." This was originally propounded by Athanæus, and while it was hoped that it would bridge the chasm between the "humoral" and "solidistic" schools, it fell far short of its purpose, and merely served to act as a "will-o'-the-wisp" to tempt the scholars of the time from the path which led so clearly and so well paved from Cos. The followers of the pneumatic school held that disease was referable to the action of the

"pneuma," the vital principle, or the universal soul, apparently a feeble attempt to infuse philosophical speculation into medicine and possibly an atavistic tendency harking back to the days of folklore.

The whole subject of Hippocratic and Alexandrian medicine was admirably and critically summarized by A. Cornelius Celsus, a Roman, who, like Aristotle, was probably an amateur physician who practiced without compensation on relatives and friends. He studied medicine as a branch of general knowledge and his contribution to medical literature was embodied in his "*De Medicina*," which in turn was one of a series of scholarly treatises, written with the idea of presenting in compact Latin form all that a Roman of the intellectual type should know. It is through this medium that we have gained our chief knowledge of the period we are considering. His writings rank with those of Hippocrates and Galen, in spite of the fact that they contain little that is original. We learn from them, aside from the theories of the variety of cults then in vogue, that surgery and obstetrics had assumed no mean places among the weapons used by physicians to battle against disease. He is one of the first to mention the use of the ligature (i. e., the complete tying off of arteries by means of cords or tapes). He mentions improvements in surgical instruments, operations for cataract, Cæsarian section, amputation, trephine operations on the skull (which had probably been done in prehistoric times), treatment of forms of insanity, and malaria. Garrison states that there are 105 editions of Celsus extant. He was, up to recent times, the most widely read and the most popular of medical authors.

The chief contemporary of the period of Celsus was Antyllus, whose name survives in the form of an association with the first radical treatment for aneurism.* His method involved the use of ligatures applied on either arterial end of the aneurismal sac, and incision, but not excision of the sac between the ligatures. This operation is practiced to-day, with but slight modifications, the chief of which is that the sac is either left unmolested or is completely removed, and is mentioned in all of the modern textbooks on surgery.

A fitting climax to this period of Greco-Roman medicine came with the studies, teachings, and writings of Galen (131-201 A. D.), who made the first specific researches in experimentation on medical subjects, and to whom we are indebted for gathering together the loose ends of the many wayward threads of ancient Roman medicine into a form from which it is possible to trace the greater part of modern medicine. He was a man of brilliant ability and keen literary talent; he had studied widely during his insatiable wandering; we are told he dabbled in politics; he was an anatomist far eclipsing, both in magnitude and type, the work of any of his predecessors; he was something of a physiologist.

He appeared on a much befogged horizon in the medical world about 170 A. D., and with a tremendous industry, set about a recapitulation of the various schools of medicine. Humoralism, the four elements of Pythagoras, methodism, empiricism, and solidism, all had their respective adherents, and

*A sac formed from, and continuous with, an artery. It pulsates and contains blood. Lues is its commonest cause, but it often occurs after injury.

with infinite care of the sensibilities of disciples of the various schools Galen added to these ideas his own pet (the "pneumatic" concept), united the warring sects under one head, substituting an "infallible" dogmatic doctrine for what had been, under Hippocratic sway, the only true way to approach the many problems of the science of medicine. With the varieties of theories of the causes of disease that were at his disposal, small wonder that he had an explanation ready for all emergencies. If the "humors" did not appear to have a clear case, it was simple enough to switch to the methodic principles, or to a combination of the humoral and "pneuma" theories, a sort of chariot drawn by the four "humoral" horses, and driven by the "pneuma," or universal soul. It seems natural that Galen should have developed a certain conceit, and natural for him to have assumed infallibility. After his death Galen was held as the ultimate authority on medical matters and it was worse than heresy to follow any other lead. As Garrison states, "from Galen's death European medicine remained at a dead level for fourteen centuries."

In spite of this fact, Galen gave us much real knowledge in beautiful literary style. He was the first physiologist of any repute. He performed experiments chiefly on apes and hogs (he was prohibited by law the freedom of the Alexandrian school), and ascertained that paralysis could be produced by severing the spinal cord. He showed the physiologic mechanism of respiration, without knowing its true function, and produced a condition of experimental aphonia (paralysis of the larynx, with an attendant loss of voice—a symptom

of certain diseases of the chest contents) by cutting a nerve (recurrent laryngeal) in the thorax. He gave us a masterly account of the treatment of tuberculosis, upon which there has been scarcely any improvement. He knew, and, according to most historians, intelligently prescribed many of the simpler drugs—opium, turpentine, colocynth, *Cannabis indica*, and others. In the pathology of to-day there are used four classically descriptive terms in defining inflammation: *rubor*—redness, *tumor*—swelling, *calor*—heat, and *dolor*—pain. These are from the pen of Galen.

As an anatomist he would have attained eminence had he lived at a time when the law permitted dissection of human bodies. As it was, with his animal dissection, while it gave material of considerable value to the subject of comparative anatomy, naturally its value from a human standpoint is slight, and his attempt to convert and make it applicable to human anatomy led him at times into grievous inaccuracies. However, he had the best understanding of the structure of the central and so-called sympathetic nervous systems of any man of his time.

To sum up, we do homage to Galen for grouping the variant cults of his day into one that was at least no worse than any of its parts. He was a pompous and dogmatic theorist, but he added much of value to the anatomical and especially the physiological annals of the medicine whose scientific meaning had been so splendidly realized by Hippocrates, and so hopelessly confused by many of his successors. Galen's cures (he admits) were marvelous; his therapeutic system small, but reasonably efficient; he was the greatest physiologist before Har-

vey; his surgical ability was his least talent; he was verbose and diffuse in many of his writings, but he was the greatest physician of his age, and his fame has lived for nearly two thousand years.

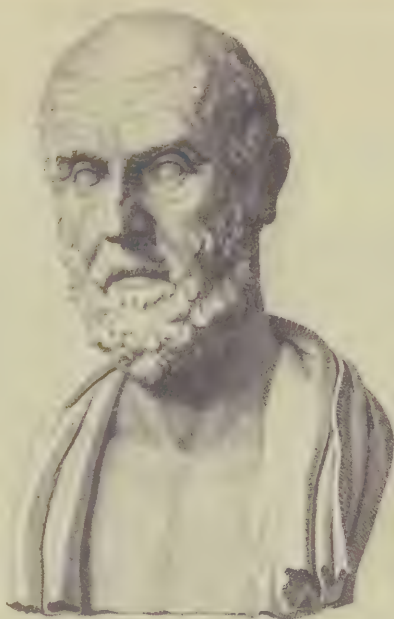
And then Rome fell. Despite the fact that this mighty race of conquerors, lawmakers, and hygienists boasted no true medical school of their own, in this science, as in all the other cultural pursuits, the setting of the Roman sun plunged the world into a long dreary night of medieval oblivion. Were it not for the zealous and patient efforts of a few, even the vestiges of Egyptian, Grecian, and Roman medicine would be lost to the science of to-day. As might be expected, efforts of historic value were chiefly in the nature of compilation. The most effective bar was put up before originality. With the single exception of Alexander of Tralles, an eclectic, who added some masterly accounts of the description of certain diseases (insanity, diarrheas, and intestinal infections), the other medical writers of the period (Aëtius, Paul of Ægina, Oribasius) were mere copyists, compilers of medical lore, but to them we are indebted for even this, living as they did during the Byzantine decline. The history of medicine has closely followed the history of the rise and fall of the great civilizations, and, like them, progress has varied directly as the ruggedness, spirituality, and solidarity of the races concerned.

In the Eastern or Mohammedan Empire, a similar phenomenon occurred, with again a brilliant exception—Avicenna (980-1036 A. D.). The Moslems were a war-loving, rugged people, and it is natural that they absorbed and reexpressed the best of the medical tradition of the time. The work of Hip-

pocrates and Galen was eagerly devoured and assiduously followed. This was particularly true of the so-called classical period of Arabian medicine, initiated by the work of Rhazes (925 A. D.), a native of Ray in Persia, who first described measles and smallpox accurately. He was, properly speaking, a follower of Galen, but, recognizing the value of the Hippocratic doctrines, was considerably swayed by them, and prospered accordingly.

The standard textbook of the Arabian school was called the "Royal Canon," and was used by physicians of that country to the exclusion of all others up to the time of the "Canon" of Avicenna. The former was written by a Persian by the name of Haly. During the eleventh century, Mesue the younger, of Damascus, a figure and personality of profound mystery, contributed a large treatise on what would nowadays be known as "Materia Medica," which went through twenty-six editions. Albucasius of El-Zahra, near Cordova, migrated to Arabia, and published what proved to be the leading textbook on surgery during this period, and indeed for some time during the Middle Ages.

The chief figure, however, of the classical Arabian period was Avicenna, a physician to the Caliph at Bagdad, and one who apparently believed in enjoying all of this earth's pleasures. He was an eagerly cultivated, a highly sociable and gregarious personality, and a clever artist at the practice of the art of healing. His greatest work in collected form was his famous "Canon" (already mentioned), which swayed European medicine for centuries. He attempted in this work to amass the entire medical lore of the times, of course a ponderous and massive work, and of course unwieldy. There was little or



HIPPOCRATES



Aufonias Coüs votis perductus in oras
Edidit hunc fœtum, veste fouëtque sua.
Hic puris repetit verbis quæcunque probantur,
Et superat molem, Forliyiæ, tuam.

AULUS CORNELIUS CELSUS

nothing of originality in any of it, being chiefly a compilation of Hippocrates, Galen, Aristotle, and the later Greek and early Arabian writers. Nowadays such a work would never be published, much less read and respected. True to the trend of the times, the work of Avicenna placed him for a time on the highest pinnacle of medical fame.

These names, it is true, represent but a few of the Arabian writers of medicine. There is no need to add more. Enumeration of all of them would only serve to bring out their chief characteristic—barrenness in the field of science. The times were increasingly felt by all men. Dogma, theory without fact, and pedantry steadily gained their vicious hold on the minds of men, and the smirking, complacent, rule-of-the-thumb medieval philosophers were coming into their own. Arabian medicine, was, after all, only translated and transferred Greek and Greco-Roman medicine flavored to suit the Arabic taste, and served on a platter of imitation. Their real contribution consisted chiefly in pharmacy and drug therapy, since neither in practical medicine or surgery did they add anything of value. They were skilled chemists, but they compare not at all with the medical fraternities of the Hippocratic or Galenic schools. True, the Arabian science was to have a beneficial effect on medieval medicine, but up to the time of the Renaissance, with its Vesalius and Paré, few names of any magnitude appear. The world had entered a desolate and unfruitful period.

CHAPTER II

MEDICINE IN THE MIDDLE AGES

DURING the time from the fifth to the eleventh centuries, there comes nearly a complete break in the continuity of intellectual effort. This is true, at least, so far as any written record is concerned. Feudalism and the ecclesiastic dogmas held undisputed sway over the minds and hearts of the world. It was heresy of the worst kind to attempt individualistic endeavor along any line which deviated ever so slightly from those drawn so sternly by the nobility of the land and the church. Again, viewing the subject as when we started (i. e., with reference to the unity of primitive religious beliefs and primitive ideas of medicine), we might be inclined to think that within a few years the world had preempted its whole doctrinal capacity, and had reverted to a fantastic, semisuperstitious medicine, which in fact admits of claim to any value whatever only by virtue of Galenic dominance. This author, alone of the ancients, was permitted by ecclesiastic consent to be read and followed. The denial by Hippocrates of the supernatural cause of disease not only resulted in his professional ostracism during the Middle Ages, but, were it not for the faithful work of a few monastic scholars, probably all record of him would have been lost.

And what was true of the work of Hippocrates was true of all that was worthy of the work of the

ancients. The greater part of the duty of preserving records of premedieval medicine was accepted by the various hermits who had retired to religious lives within the monasteries, for which the period is famous. These records were written generally in Latin, and in many cases afford us the only approach to original sources of work before the fifth century. Like much of the writing of the Arabian school, these monastic documents were compilations and translations, serving only to fan the spark of medicine, and adding little or nothing to its fire.

A survey of the history of the Middle Ages would easily explain the dearth of originality. Men were led—and the leaders constituted an authority which reached its most dangerous and despotic heights in feudalism. Ecclesiastic control was absolute. A tremendous reaction against democracy occurred. The insoluble mystery of the ages—materialism *vs.* vitalism—almost completely filled the intellectual attention of philosophers. Allbutt ascribes to this most hopeless form of metaphysical speculation the separation of the professions of medicine and surgery, stating that the latter was classed among the “manual arts and crafts,” and as such held in abhorrence by the “top-heavy, feudalized scholastic.” Later, this proved to be the grossest fault which came as a heritage of these fault-filled years, because of the fact that the art of surgery was forsaken by the fastidious “medical logician,” and relegated to the unscrupulous hands of barbers and mercenary quacks. Small wonder it fell into disrepute, and that during the next fourteen centuries we learn of the most outrageous practices parading under the name of surgery.

To the Benedictine order we owe a special debt for assuming charge of the "roles of medicine." At their mother-abbey at Cassino, during the sixth century, members of the order were urged by Cassiodorus to study Hippocrates, Galen, and other classics. One school stands out as the most prominent and progressive of the Middle Ages. Its origin is totally unknown. It was located not far from Monte Cassino, and was held by some to be an outgrowth of the Benedictine school of that place, but is now generally accepted to have been of secular origin. Here occurred a phenomenon which has ever since been typical of the relationship of the church with medicine—the founding and maintaining of a well-equipped hospital. A number of schools sprang up in the little Roman colony; law and philosophy were taught, and by the ninth century the term "Salernitan physician" meant the best of the world's healers. William the Conqueror is said to have repaired to their hospitals seeking restoration to health during the tenth century. A female physician—the celebrated Trotula—became a member of the teaching and practicing staff during the eleventh century. During the thirteenth century, the revival of Arabian medicine gradually excluded all others, and when outdone by the schools at Naples and Montpellier the Salernitan school slowly declined. The university itself was ultimately dissolved by imperial edict of Napoleon I in the nineteenth century.

Considerable practical experience and sound good sense is evidenced in the writings of the school of Salerno. One is reminded of the ideas of Hippocrates in reading these authors. The most famous product of the school is, curiously, a poem called

"Regimen Sanitatis Salerni," alleged to have been written for the "king of England," perhaps for William the Conqueror or his son. Of strictly professional import a few others may be mentioned—"Anatome Porci" (the dissection of the pig) by Copho; a great compendium by Joannes Platiarius, believed to be the husband of Trotula, the famous female physician of Salerno, and the "Antidotarium" by Nicolaus Præpositus, a compilation of pharmaceutical formulæ which was the standard of its kind ever after. A popular author of the time was one Gilles de Corbeil (Aegidius Corboliensis), who also wrote in Latin hexameter. Two offerings, for which he was especially famous, concern the urine and the pulse, works which are now numbered among the best of the classics. Aside from the naturalistic methods of this school, it also followed the Hippocratic precepts to a limited extent in its treatment, more particularly along the dietetic lines insisted upon by the Coan school. Anatomy was neglected. Surgery had not yet begun to show the effects of its prostitution at the hands of mountebanks, and in the other branches the broad fundamentals of medical doctrine remained unchanged.

During the eleventh century, Hippocratic and Galenic principles with their Arabic coloring had begun to be known through Latin translations in the West. Constantinus Africanus, a member of a Catholic order, wrote the first of such translations, treating particularly of Haly—the two Greek classics did not come until later. The Crusades were of course instrumental in bringing about this refusion of East and West, and the conquest of Toledo was the important medium of affording the western scholars contact with the Moors of Spain. In this

work of the amalgamation of classic and medieval trends, Jewish scholars under the direction of Christian ecclesiastics were especially useful. Gerard of Cremona, a famous physician of Toledo, translated Avicenna and others by command of Frederick Barbarossa. Even Salerno felt the undertow of the wave of classic authorship which this revival spread throughout civilized Europe, following this devious path we have traced, and indeed from the thirteenth century Arabian medicine held an equal if not more prominent place with the older medieval science in the Salernitan doctrine.

Universities sprang up in swift succession. Philosophy, theology—all of the known academic studies—were widely pursued and medicine shared a proportionate diffusion. Montpellier was an especially enterprising school of the twelfth and thirteenth centuries, its progress being in direct ratio apparently to the decline of the famous Salernitan University. Paris, Padua, and Bologna became centers for scholastic endeavor and vied with each other in their efforts to found and perpetuate the best medical center. Saliceto, an army surgeon of Bologna, and later of Verona, was a prominent figure in this period, ably succeeded by his pupil Lanfranchi of Milan. The former played a distinctly important and beneficial part in the science of his time, chiefly by virtue of his efforts to harmonize again discordant medicine and surgery, a pair that must of necessity go hand in hand, but which we have seen had been so completely separated by the efforts of the quasi-scientific feudalists. Saliceto also must be remembered for the fact that he returned to instrumental surgery as opposed to the sweeping Arabian doctrine of cauterization. He

and his able pupil first demonstrated the proof of venereal contagion.

Lanfranchi, himself an excellent surgeon, stoutly maintained the contention of his master that there was no true separation of the arts of medicine and surgery, and roundly abused the lowly types to which the instrumental branch had been consigned. He performed his best work at the Collège de Sainte Come in Paris, where he and Guy de Chauliac were the foremost surgeons of this locality and time up to the period of Ambroise Paré. He gave us classical descriptions of cerebral concussion, fracture of the cranium, and some especially valuable differential diagnoses, such as that between cancer and simple hypertrophy (an increase in the true glandular structure) of the breast, and between bleeding from an artery and from a vein. It is remarkable that this last difference was not known to Galen or Avicenna. Nowadays, millions of individuals have taken more or less instruction in first aid diagnosis and treatment, and could easily distinguish between the alternating spurts of arterial bleeding and the slow continuous oozing of venous blood, but to these medieval surgeons it was a subject of much discussion and bitter debate. A complacent world often views an obvious and easily proven fact with distrust and disbelief, especially if its acceptance means a change in the former order of things.

Another prominent name is that of Henri de Mondeville (1260-1320), a contemporary of Lanfranchi. It must be understood that Galenic influence had caused the germination of the idea among the Arabians that the formation of pus was the probable and desirable concomitant of the healing of all

wounds. Hence the term "laudable pus," an expression used in attempting to justify what we now know to be the least desirable form of body reaction to a surgical wound. It always means infection, when occurring in such wounds, and, since the Arabians knew nothing of asepsis or antisepsis, it must have been a fairly constant occurrence to see their incisions heal by the slow, dangerous route of pus exudation, granulation, and scar formation. This great fallacy of "laudable pus" was not to be successfully contradicted until the advent of Lord Lister in England and his use of carbolic as an antiseptic agent. It is interesting to note, however, that Borgognoni (1205-1296), Hugh of Lucca, his father, and Henri de Mondeville bitterly opposed the idea of the necessity of "coction" as a part and parcel of the natural healing of wounds, Henri even going so far as to advise that "wounds dry much better before suppuration than after it," and on this account to wash them clean and put no salves or ointments on them. These assertions place such men in a unique position, and emphasize the fact that great discoveries are usually the product of long collections of ideas, coming frequently from many sources. No tribute is great enough for Lister, but in some measure it might well be said that these men, as well as Pasteur, anticipated him.

Probably the greatest name in medicine of the fourteenth century was that of the French surgeon Guy de Chauliac (1300-1370). Educated chiefly at Montpellier and Paris, with an anatomical curriculum followed at Bologna, he set a high standard intellectually and professionally. His work was done largely at Avignon as physician to the Pope (Cle-

ment VI) and was of the highest order possible at this time. He was a surgeon "of considerable parts" and keenly sensed the danger of leaving this form of treatment in the hands of "barbers, sow-gelders, bath keepers," and their ilk. He operated radically (not in the modern sense) for cancer, hernia, and cataract (hardening of the crystalline lens of the eye—a condition which commonly results in blindness). He employed an inhalant mixture of "opium, hyoscyamus. . . . and hemlock" which produced practical anesthesia. He treated fractures of the great bones much as we do to-day, but as if to offset all his brilliant ability he stubbornly held to the doctrine of "laudable pus," effectively closing debate on a proposition that bid fair to be settled rightly, and in so doing he turned back the march of surgical progress until the nineteenth century. Other surgeons of the time were John Ardern, an English army surgeon, Arcolani of Padua, and the Flemish pupil of Lanfranchi—Jean Yperman (1295-1351).

Knowledge of what, from this time on, we may call internal medicine comes to us in ecclesiastical garb, chiefly Galenic in origin. Gilbertus Anglicus and John of Gaddesden (Chaucer's "Doctor of Physic") contributed volumes of compiled matter filled with the "logistic maze" of medievalism and of little or no value. We also need mention one who was among those "strange sons of the earth" who sought a "universal elixir" or panacea—Arnold of Villanova (1235-1312). This fantastic hope of the ancients has given us one great explorer and many hopeless, empty lives. It must be noted that anatomic dissection of human bodies was again coming into its own. In 1240 the

Emperor Frederick decreed that dissection of human subjects be permitted and in most of the larger medical centers it began to be part of the regular medical course by the middle of the fifteenth century. Almost the only book on anatomy for the fifteenth and sixteenth centuries was that of Mundinus (1275-1326).

CHAPTER III

PERIOD OF RENAISSANCE AND REVIVAL (1438-1600)

TO one who has read anything of the world's history the intellectual and cultural revival of the period from 1440 to 1600 cannot fail to appeal as one of the great milestones of human progress. As in the arts, where the old Greek standards were revived and copied, so it was in medicine. For centuries we have seen how the despotism of feudalistic times cramped imagination and originality. We have seen the effect of that worst medieval mistake, the divorce of medicine and surgery, which has borne out an axiom of scientific work: specializing, to the exclusion of correlated subjects, means failure. The whole medical and surgical world believed that the proper way for wounds to heal was by the formation and ultimate absorption of pus. The worst of Galen, the best of Celsus and Guy de Chauliac, and the average of the copyists of the Arabian school held undisputed sway in scientific medicine. The theologians, than whom none held greater power, laid down stern rules of conduct and thought. The intellectual world, such as it was, harbored almost entirely an unchanging dogmatic scholasticism.

It must not be assumed that the revival of Greek culture occurred over night, nor indeed that its revival was at once a beneficial circumstance. The arbitrary dates of the Renaissance merely serve to

set aside a period of preparation, as it were, for the amazing discoveries and scientific achievements of the seventeenth to the twentieth centuries. We are still to have the "literary massivity" which characterized the period we have just briefly considered. But slowly and surely the Greek sun, which had risen with Hippocrates and set with Galen, was sending its dawning rays of Paré and Vesalius to awaken a lethargic world to a new and more glorious day. Great names begin to appear and especially great ideas. We approach a time when we can better afford to dispense with the consideration of periods, and treat of events. Possibly the greatest of these events was nonmedical, but in this science, as indeed in every phase of the civilization of man, it was one of the greatest events of all time—the invention of printing.

From our standpoint, however, we must mention primarily an accidental discovery by Thomas of Sarzona, afterward Pope Nicholas V, who, in 1443 in Milan, found a manuscript of the "De Re Medicina" of A. Cornelius Celsus which we have mentioned. It was printed and fairly widely circulated following the fall of Constantinople and the scattering of Greek teachers. The famous press of Aldi added an equally important "*editiones principes*" of Hippocrates and Galen in the original. Other printing houses and publishers sprang up all over Europe and now, instead of garbled translations and opinionated revisions of the great Grecian classics by men like Avicenna, the world had easy access to the original writings of those unequalled masters of Hellenic medicine.

Perhaps the greatest advances of the Renaissance were made in the fields of anatomy and drug therapy.

We have already seen that in most large medical centers human dissection was permitted by law. As the practice became more general and the work more accurate, a large objective branch of medicine came into its own, making rapid strides and culminating during this period with the work of Vesalius and with the great discovery by Harvey of the circulation of the blood. But remembering Galen's fantastic but interesting collection and writings of plant lore, it is easy to see the result of the revival of his writings. The discovery of America and its immense new flora added its quota to the growing science of botany and later, pharmacology.

Of names there begin to be many—each worthy of mention and tribute. A group, however, instead of an individual, attracts our first attention. They are usually called the “medical humanists,” scholars rather than physicians, forwarding the cause of letters rather than medicine, and men who, though only exposed to the essentials of Greek science, became steeped with its spirit, and enthusiasts of its virtues. Such were Leonicensus of Vicenza, and Giovanni of Montanus, in Italy; Guilielmus Copus and Günther of Andernach, in France, and the greatest, Thomas Linacre of England. Some time later, Janus Cornarius and Leonhard Fuchs in Germany; John Kaye, or Caius, in England, and François Rabelais, who is perhaps best known as a humorist, in France, took up the lightening burden. These men aimed in common to condemn all things bearing the stamp of what they called the “barbarism of the Dark Ages.”

The medical humanists typify a spirit of the times which was, next to the introduction of printing, to be the greatest dynamic force of modern medicine,

the spirit first of criticism, and later, its more useful mate—inquiry. The revival of the originals of the old masters immediately branded a great many alleged copies as utterly spurious documents, and it was not long before men began that eager search for original sources which characterizes all of the best of modern medical works. In turn this search developed into seeking into the “why instead of the how,” cause instead of effect, logical thought instead of unguided practicality—in other words, a search for truth.

And we meet with three great names—Paracelsus, Vesalius and Paré—rugged, dominating (one even domineering) personalities, who by their sheer genius have made their names immortal; independent thinkers beautifully free from the hidebound doggedness of the Medieval Period; the first scientific physicians after Hippocrates, and medical heretics of the first water. Since with each of these names is linked a great medical idea, it is best to consider them separately and to relate their stories.

During the same years that the group of medical humanists flourished throughout Europe, there dwelt in Germany a strange and brilliant man. Paracelsus, or Aureolus Theophrastus Bombastus von Hohenheim, son of a physician, was born in Einsiedeln, Switzerland, during the year following the discovery of America. His early training reminds us of that of Galen, as indeed do his personality and activities. He traveled widely throughout Europe while a young man. He was a convivial and indeed a profligate spirit, claiming by preference association with barbers, monks, surgeons, alchemists, clairvoyants; often welcomed in hovel and

palace as well, enduring the socially high but favoring the socially low comradeship—a rolling stone and a roving, gypsylike personality. His exposure to knowledge was great and his absorption of the fundamentals of most of the cultural pursuits of his day was proportionate. His particular interest seems to have centered about medical subjects and he soon came to the conclusion that medicine as taught and practiced by his contemporaries was haphazard guesswork, founded on the vaguest theories, and colored with the mystic dreams of superstition—in short, worthless, and he forthwith proceeded with brazen tongue to sound the alarm throughout Europe against practically all of the recognized authorities of his time.

He was made professor of medicine and city physician at Basel in 1527 and opened his series of lectures there by burning the books of Avicenna, bombastically claiming that his own shoe buckles were more learned than Avicenna and Galen put together. Hippocrates, alone, he treated with high respect. With his violently radical ideas, his arrogant and conceited actions, his vitriolic storm of abuse against some of the oldest traditions of his day, he brought upon himself, in logical sequence, hatred and persecution. Among his almost universal enemies of the day, he earned the title of “the Luther of medicine,” and like the great Protestant, the name has lived to render him tribute among his friends of later periods. We learn with but little surprise that in 1528 (one year after his appointment) he was forced to leave Basel following a squabble about fees, and, resuming his insatiable wandering, practiced during one time and another throughout practically all of Germany. His death

occurred in 1541 as a result of a drunken brawl in Salzburg.

He reminds us of Dr. Samuel Johnson. Bullying and thundering his coarse and often obscene arguments, he pompously told the world with a sort of "Ich und Gott" attitude, that Hippocrates and himself were the only authorities of even the slightest value. With a broad sweep of his iconoclastic arm he shattered the traditions of the ancients and damned to ignominy all his contemporaries, calling the latter "whited sepulchers," saying, "There is no hope for the elder ones, who are like untrained old dogs, and can learn nothing, but for the benefit of the younger I will expound the true and divine medicine." With the exception of Apollo, Machaon, Hippocrates, and himself, he held all physicians as quacks, charlatans and thieves, and peremptorily dismisses Galen with "he cannot boast of a single experiment, but learnt everything from others. He opposes nature in all things, and is therefor a liar who can do nothing but collect pearls, and turn them into pebbles; wherefor he is in the lowest hell, whither his disciples will follow him."

In this heavy artillery style, he blew aside the walls of dogmatic medieval medicine. What did he erect in their place? Writing in his native German, he founded a doctrine of his own, using the views of the Neo-Platonists, according to his compatriot expositors. He raised his temples of Medicine on four pillars—Philosophy, Astronomy, Alchemy, and the Virtue of the Physician. Man, according to this quarrelsome bully, is a "microcosm," which is a compact model of the "macrocosm" (universe), each containing all the elements and parts of visible nature, the sun, moon, stars and earth. Disease is

caused by the action of various constituents of the macrocosm, and it follows that "anatomy is a study for idle fools and butchers," whereas the physician must needs "take all knowledge as his province," since "medicine is the highest and widest of all sciences, since it includes all from theology down." Life is a germinative process in perpetuity, controlled, so far as disease and termination are concerned, by "Archeus," or the indwelling spirit. He contradicts himself elsewhere by saying that five beings (*entia*) are the causes of all diseases, each of these exercising this baleful function. These five are the "*Ens Veneni*," or poison; the "*Ens Naturale*," or a being within the body itself; the "*Ens Spirituale*," or spiritual entity; the "*Ens Astrorum*," an astrologic concept of the influence of the stars, and an "*Ens Dei*," the influence of God. After describing the first four, he blithely states that "they apply only to Turks, Saracens and other infidels, whereas for Jews and Christians," the last named (*Ens Dei*) is the only cause of diseases, which "are sent as purgatorial punishments."

Then another contradiction follows. He states that "the immediate cause of disease is a change in the three mystic elements, salt, sulphur and mercury." Chemical and other changes in these elements, which in the healthy body are so intermingled that they cannot be distinguished, become the causes of pathologic conditions. He seems to have superimposed these fanciful terms and ideas upon the "humoral" doctrine of Hippocrates, merely "to make it harder!"

Remedies were naturally of such a character as to counteract the "essence" of disease. We have a parallel nowadays in the term "specific" (i. e., a particular drug used to combat the etiology of a

particular disease—such as quinine in malaria). He used the term “arcana” to denote these remedies. From the doctrine we have last mentioned concerning Paracelsus’ idea of the cause of disease, it may be understood why he attached great importance to chemically prepared (inorganic) remedies, and it is for this fact that we are chiefly indebted to him. He describes a fairly large number of compounds of the heavy metals, especially prominent being his use of antimony and its salts. He also gave us, according to most historians, the first preparation of the alcoholic tincture of opium and called it by the name by which it is known to-day—laudanum.

To conclude with this great figure of medicine, Paracelsus may be described as the founder of chemical pharmacology. His wide knowledge of chemistry, though highly tinged with the quackery of alchemy, undoubtedly engendered this type of effort, and he has given the world considerable of value. The use of antimony became a sort of “recognition badge” of the man and his followers. His direct contributions to the theory of medicine were of questionable if any value. His works serve to embody the spirit of the times, and for his blind courage of thought and his fearless, if somewhat dubious originality, we must place him among the great. But in medicine, as in all other arts and sciences, we seldom make progress by quarreling, and, given the humility of a Vesalius, Paracelsus would have been an altogether admirable character. As it is he is the most belligerent figure we will encounter in this history. He was the Bolshevik of medicine.

The second of the triumvirate of great names of the Renaissance is that of Andreas Vesalius. Born

in 1514, in Brussels, of German origin, this man became the most famous anatomist of his time, and helped prepare for the discovery which revolutionized physiology and medicine—that of the circulation of the blood. He became a pupil of Jacobus Sylvius, who had, throughout his whole scientific career, espoused the cause of the infallibility of Galen. Vesalius became one of the professors at Padua in 1537, where, in 1543, when he was 29 years old, he published the work which was to completely change all future study of anatomy. With the closest application to his work during five years in this great medical center, his natural originality and independence found their means of proper expression, and his volume *De Fabrica Humani Corporis* completely overthrew, or rather with its brilliant and compelling truth supplanted, the traditions handed down by Galen, which had dominated anatomists and physiologists for fourteen centuries. His worth lies not so much in his discoveries, for in these he was equalled if not surpassed by Eustachius and Fallopius, two of his eminent contemporaries, but rather we are indebted to him for the fact that he recognized that “to vilify Galen was to praise him,” to attempt to refute him, served only to give him more zealous adherents. Vesalius wrote his own anatomy, and he wrote only concerning that which he saw and felt. It is interesting to note that Raphael, Michelangelo and Leonardo da Vinci, with others of the unequalled masters of this period, were more or less directly responsible for the origin of the new science of anatomy. These famous men, with the discerning eye of the painter and sculptor, reproduced what they saw. Their heroic masterpieces might well be

used to denote surface and regional anatomy. It is known that at least one of these artists quarreled with the anatomists of his day about the presence of one of the muscles of the thigh, and although the artist had never dissected, nor seen dissected this portion of the human body, he was right! The demand for knowledge made by these masters, of structures beneath the skin, began to be supplied first by Berengario of Carpi, professor at Bologna, and later by Vesalius and his contemporaries.

Probably every revolutionary act has its relatively few proponents and its correspondingly many opponents. It was certainly so with the new assertions of Vesalius. Common consent had breathed the breath of infallibility into the mouth of Galen and he had continued to live in name and his written word had been the beacon light of all medical endeavor up to this time. The Renaissance anatomist dared to assert that Galen's idea of the number and location of the bones of the body was wrong! He completely concurred with the latter's statements concerning the spinal cord, but, anticipating Harvey, he truthfully stated that he was unable to see or feel the minute pores which, according to Galen, served to permit the flow of blood from the right ventricle to the left, and what is most important, and typical of the man, Vesalius stated that because he could not see and feel them, he did not believe they were there! *Veritas vos liberabit!*

Like Luther, Paracelsus, and indeed every revolutionist, Vesalius at once gained bitter enemies. The first sign of disapproval came from his former teacher, Sylvius, and it came in the most abusive and unwarranted form. Openly scoffing at the new ideas of his pupil, this Galenist refuted every state-

ment which opposed the old Grecian tyranny, writing in a coarse vein, and ultimately joined a group which by trickery and deceit strove its utmost to oust the "upstart." Incensed at the unfair treatment, the great pioneer, it is said, in a moment of depression destroyed what he had written, and, forfeiting his position at Padua, became court physician to Emperor Charles V. His pupil, Fallopius, took up his old duties and the latter's success must have done much to cause the mental suffering of the latter part of the master's life. He left, during 1653, for Jerusalem, on a penitential pilgrimage, and in the following year found, while returning to Madrid, that the chair of anatomy at Padua was empty on account of the death of Fallopius, and heard that it was again to be tendered to him. But he never had the opportunity of gaining his former position in the living medical world. Shipwrecked on the island of Zante, Vesalius died, friendless and alone; the nature of his last illness is itself unknown.

His is one of the most romantic names of all time. Unlike his contemporary Paracelsus, who, though he braved the sea of tradition, sailed an unworthy craft, this brilliant figure is given to us as an example of the purest worth of the times—constructive criticism. True, like Paracelsus, he ignored with complete abandon the Galenic concepts, but here the likeness ceases. Vesalius, without hope of reward, and in the face of opposition ranging from "faint praise" to insult, recorded the truth as given him through his eyes and his hands, and in his own name and time founded the science of human anatomy on an accurate dynamic basis. Truth must always be the limit of human endeavor, and no man could have done more.

A very different manner of man from either Paracelsus or Vesalius was Ambroise Paré. Born near Laval, in Maine, France, in 1510, he received his early medical education at the hands of the itinerant barber-surgeons, a sect of which we have seen the disreputable origin, and which during the Middle Ages and the Renaissance managed to retain its disrepute. As to who his actual teachers were is unknown, but we first hear of him professionally in Paris in 1533, where he was house surgeon at the Hotel Dieu. After receiving training there in the dressing of wounds during three or four years, he set up in private practice in Paris, only to become an army surgeon eight years later and, as a result, gained the fame for his work on the many battle fields of France. During this period there was no true medical corps in the French army. Those of the nobility who could afford it had their own hired barber-surgeons and their private physicians, who in the stress of battle were allowed to dress the wounds and care for the diseases of the soldiers. Such a man was Paré. Originally a follower of Col. Montejan, without rank or salary, he describes his unique experiences and curious fees in his "Journeys in Diverse Places," a small volume written as a defense against a bitter attack made on him by the Dean of the Faculty of Paris, when the famous French surgeon made the statement concerning the healing of wounds for which he is especially noted. It will pay the reader to peruse this little work (which has been translated). It not only portrays the successful march of a surgical genius, but affords an excellent opportunity to appreciate the medicine, surgery, and warfare of the period. We learn, for instance, that the custom was for the barber-sur-

geons to treat all gunshot and amputation wounds with hot oil. They had not yet learned asepsis or antisepsis, and used this method of cauterizing and dressing a wounded surface. The ligature was not in use, and had not been seen since the time of Celsus. Hippocrates had been wrongly translated and had been given credit for saying that all wounds of the brain or any part thereof were fatal, and this was held as an axiom of war surgery.

Ambroise Paré corrected these fallacies once and for all. One night, at the battle of Turin in 1537, following a bloody engagement which had lasted throughout most of the day, he was dressing wounds. Obeying the orthodox principle of his day, he poured "hot oil of elders, mixed with a little treacle" over all the open wounds, with the idea that all such wounds were poisoned and that this was the most effectual means of treating them. His own graphic words follow:

"At last my oil ran short, and I was forced instead thereof to apply a digestive made of the yolks of eggs, oil of roses, and turpentine. In the night I could not sleep in quiet, fearing some default in not cauterising, that I should find the wounded to whom I had not used the said oil dead from the poison of their wounds; which made me rise very early to visit them, where beyond my expectation I found that those to whom I had applied my digestive medicament had but little pain, and their wounds without inflammation or swelling, having rested fairly well that night; the others, to whom the boiling oil was used, I found feverish, with great pain and swelling about the edges of their wounds. Then I resolved never more to burn thus cruelly poor men with gunshot wounds."

This great surgeon also revived the use of the ligature, making possible the relatively safe operation that amputation is to-day. It is difficult for us

to conceive the importance of such fundamental principles. First used during the time of Celsus, the plan of tying off arteries either preceding or following their cutting, had fallen into disuse. Imagine the difficulty and especially the danger of trying to stop the bleeding in a severed artery as large in circumference as the ordinary lead pencil! (This is the usual size of the femoral artery which is cut in high amputation of the leg.) And yet, for 1,400 years we have no record of the simple expedient of tying such a spurting vessel—we hear only that such were cauterized. Paré also records cases where pieces of metal (spears, swords, fragments of shell, etc.) were forced into and, in some cases, clear through the brain, and in spite of the Galenic dogma to the contrary, we read his humble refrain, “I dressed them and God healed them.” He is also credited with the invention of certain new surgical instruments, with first observing that “sound teeth, accidentally knocked or pulled out, may be successfully replaced in their sockets,” and with the reintroduction of an obstetric operation called podalic version. This is an expedient often resorted to nowadays when rapid delivery of the pregnant woman is indicated, and the circumstances do not admit of simpler methods. It consists of introducing the carefully cleaned hand into the uterus, seizing one of the feet of the child, and by completely turning it (version), effect extraction, feet first, by slow traction on the feet and legs. The operation had fallen into an ill-deserved disrepute and it remained for Paré to make it a valuable and comparatively safe aid in obstetric procedure. It has saved the lives of thousands of women and children.

There were other and important and successful men connected with the medical science of the Renaissance. Peter, or Pierre, Franco, a Huguenot, published in 1556 the first account of what is probably the most important surgical operation in existence—that for the relief of strangulated hernia. It is one of the few life-saving emergency operations that are performed throughout the world to-day. Franco also first performed the operation in which entrance into the bladder is made by incision through the abdominal wall (suprapubic cystotomy). Another interesting figure is that of Tagliacozzi, professor of surgery at Bologna, whose fame depends curiously enough on the fact that he made new and beautiful (?) noses! Plastic operations of this kind had been performed by the Hindus, but the renown of Tagliacozzi spread throughout Europe, and so far as we can ascertain, seemed based on this one operation. He suffered a curious fate. Medieval theology was still strongly buttressed within its ecclesiastical stronghold and the churchmen of Italy bitterly attacked this compatriot surgeon who, they claimed, committed a sacrilege in thus “impiously presuming on the function of the Creator,” and condemned his work as “a product and instrument of the devil”! Shades of John Hunter! What would these worthy ecclesiastics have to say about the remarkable work done within the past four years, in removing scars and deformities of the faces of soldiers in the World War? Noses, ears, eyes, indeed whole faces have been reconstructed by our plastic surgeons, and the results have, at times, been truly gratifying. Even after the unfortunate Italian’s death, his insatiable enemies claimed that “the nuns of a convent in the neighborhood of Taglia-

cozzi's grave heard a terrible voice 'Tagliacozzi is damned!' " and it is recorded that the body was exhumed and, after excommunication of its soul, buried in unconsecrated ground.

Of the true physicians of the sixteenth century, one of the most famous and interesting was Amatus Lusitanus, a Jew, born in Portugal, who, in spite of forcible baptism during his childhood, continued secretly to follow the religious precepts of his fathers. Like the three great men we have mentioned, he dared to contradict the unsupported theorizing of some of his contemporaries, and as a consequence was forced into exile, finding a haven at last among the Turks. Here, in the city of Salonica, he published his famous "Medical Cures," 700 in number. He was a naive and witty writer. One of the fashions much in vogue to-day among some of the hairdressing establishments of this country was practiced by Amatus. He writes: "I have prescribed many and various compounds for dyeing girls' hair auburn (*fulvus*), for we must comply with them even against our better judgment. I record the following not only because it is the simplest, safest, and most effective, but also because my very dear friend, Maria Baldwin, a noble Florentine lady, never used any other. Take Arabic *alkanna* (*henna*) such as merchants bring from Greece or Morocco, and make it into a paste with a little warm wine. Then anoint the whole hair up to the roots therewith. Keep the head covered for twenty-four hours; then wash in warm wine and comb with a long-toothed ivory comb. Nothing more is required, so great is the power of this drug." This and the following astute observation on a neurasthenic abscess are taken from Withington. "A noble Frenchman, procurator

of King Henry II at Ragusa, got an affection, not of his reason, but of his imagination, for he fancied he had an abscess in his side, and offered great rewards to whoever would cure him. I found him in excellent health, with a rosy face and good pulse. He ate like a bull, drank like a Frenchman, and slept profoundly, but could in no wise be cured of his delusion, and proceeded to make his will and to give all he had to strangers, except one flagon which he hugged, *non secus ac elegantum puellam* (not unlike he might an attractive maiden), for it was full of generous wine." Amatus administered large doses of hellebore and senna to no purpose, till, remembering how Alexander of Tralles cured a patient who thought he had a serpent inside him, he determined to do likewise, and performed an imaginary operation with complete success on March 8th, 1557, the pus being represented by a mixture of hen's blood and milk.

And so it went. Constantly stumbling against the superstition and almost unchangeably fixed ideas of the Dark Ages, vigorous, original minds took the first, halting steps of progress. Here a chemist dared to defy the Galenic tyranny, and in so doing, founded a great branch of medicine. There a surgeon saw with his own eyes that a wound healed better when hot oil was not poured on it, and he had the courage to desist from this kind of treatment, though it had been decreed by the ancients, whose word was law, as the proper thing to do. A romantic anatomist began to see and tell the truth about the elaborate structure of the human body—in short, men began to seek and find. New and tremendous problems presented themselves to add stimulus to these eager versatile minds. Measles and smallpox

appeared in epidemic form in Germany and Scandinavia during the fifteenth and sixteenth centuries. Leprosy and epidemic chorea had appeared in force, and in the fifteenth century following the return of the Columbian sailors, syphilis appeared and spread throughout Europe with a rapidity and malignancy almost incredible. The best of Galen's concoctions were helpless before this terrible malady, but a noticeable change occurred in the sixteenth and seventeenth centuries when mercury, first used by Berengario da Carpi in the form of inunctions, began to be relied upon almost completely in the treatment of this great social plague. Its history is extremely interesting, but somewhat obscure. The French called it the "Italian disease" and the men of Bologna retaliated in kind. For a century it spread with extraordinary virulence and was often attended with a high mortality during its acute and secondary stages, a characteristic which to-day it fortunately does not exhibit.

The effects of the Renaissance were not on the fundamentals of medical science, and yet a few foundations of its dynamic branches were laid. Especially important was the beginning of organized clinical instruction. We have no Michelangelo in medicine, but we sense the first tugging of impatient minds so long at a standstill, harnessed to the cart of medievalism.

CHAPTER IV

MEDICINE IN THE SEVENTEENTH CENTURY

THE years of the calendar mean something in history only when they serve to mark the time of the appearance of a great man or a great idea. Early seventeenth century medicine shows nothing to distinguish it from that of the sixteenth, until the appearance in 1628 of the discovery of the circulation of the blood, by William Harvey, heralded the approach of a series of unequaled scientific achievements. As Garrison describes it, the century marks an era of intense scientific endeavor, and during the following hundred years discoveries of the highest order followed in quick succession. The work of Harvey, however, stands alone among the gems of experimental physiology. It is the greatest and most beautifully demonstrated discovery of its kind.

William Harvey was born at Folkestone, Kent, England, on April 1, 1578. He received his early education at King's School, Canterbury, and at Caius College, Cambridge. Following one of the best examples of the time, he entered the medical school at Padua in 1599, became a pupil of aptness under Fabricius and Casserius, and received the degree of Doctor of Medicine from this famous university in 1603. He later received the same degree from Oxford and Cambridge, and following

his return to his native land became physician to St. Bartholemew's Hospital and Lumleian lecturer at the College of Physicians. It was while he was delivering this series of lectures that, in 1616, he first publicly announced his revolutionary theories concerning the phenomenon with which his name is always so intimately associated. Harvey became, in 1618, physician to the king (James I)—a position which he maintained until after the Civil War. His death occurred June 3, 1657.

A brief idea must be given as to the status of the problem of the circulation of the blood before Harvey's work. Again we must refer to the fountain-head of medieval knowledge—Galen. Most physicians of the seventeenth century believed that "the object of the pulse was the same as that of the respiration," namely, that when the artery was at its point of greatest expansion (they used the term arterial diastole), it was filled with "air, which had been drawn through the skin," and when the artery had "contracted" (arterial systole), it had emitted through the pores of the skin "the air, spirits, or fuliginous vapors." This, in spite of the fact that Galen had shown experimentally that the arteries contained only blood! The latter did not admit, however, and in fact it seems likely that he had not the faintest conception of the fact, that the pulmonary (lung) circulation had anything to do with aerating the blood. He, of course, knew that blood did flow through the lungs, but supposed, as did all of his followers, that this was only for the purpose of nourishing the lung tissue itself. Galen believed that the blood passed from the right to the left side of the heart through small pores in the wall separating the two ventricles, and that the blood contained

in the arteries and veins of the pulmonary circulation was a very small part of the amount in the body, and escaped the passage through the "pores" because it was needed to supply the delicate lung tissue. Galen did not know of the capillaries (nor did Harvey, for that matter), and the former is responsible for the doctrine that the blood is filled with "natural spirits" in its transit through the liver, with "vital spirits" in the left heart, and that the latter are changed into "animal spirits" in the brain, all this fantastic mechanism being under the control of his famous "pneuma." He also assumed that air was absorbed from the lungs through the great pulmonary veins, but in so doing merely followed the general law that all vessels containing arterial blood received their "air" through the nearest outlet to the atmosphere. This type of hazy theorizing apparently satisfied the world up to the time of Harvey. In general it was held that the arteries performed the same essential function as the lungs and there was no conception of a circulation fluid, passing from the left ventricle out into the body through capillaries into veins, back to the right heart, to the lungs for oxygenation, and thence back to the left heart via the pulmonary veins.

Facing these curious but firmly established ideas, fathered by the great Galen, Harvey performed the most brilliant feat in the history of physiology. Backing each step with careful experimental proof, he proved for the first time that the blood moved in a continuous circle, that it did not vary in volume, and that at no time did the closed system of arteries and veins contain any "air or fuliginous vapors." He proved that the popular idea concerning the so-called systole and diastole of arteries was not a

function of the respiration, but resulted merely from the fact that during expansion the arteries were filled with blood pumped from the heart under a somewhat increased (systolic) pressure, and that the contraction (or, more properly, relaxation) of the arteries was due to the manifestation of the tone maintained by the elasticity of the arterial coats. He first made a careful survey of all the literature on the subject. For twelve years he continued to familiarize himself with the known facts concerning the circulation. Then in his Lumleian lectures appeared the first statement of the results of his experiments and the formulation of his theories. First he showed how inadequately the existing theories explained various well-known phenomena, and then by means of vivisection experiments and the most logical reasoning demonstrated his proof. His own words show the magnitude of his task and the nicety of his work.

“When I first gave my mind to vivisection, as a means of discovering the motions and uses of the heart, and sought to discover these from actual inspection, and not from the writings of others, I found the task so truly arduous, so full of difficulties, that I was almost tempted to think with Fracastorius, that the motion of the heart was only to be comprehended by God. For I could neither rightly perceive at first when the systole and when the diastole took place, nor when and where dilatation and contraction occurred, by reason of the rapidity of the motion, which in many animals is accomplished in the twinkling of an eye, coming and going like a flash of lightning; so that the systole presented itself to me now from this point, now from that; the diastole the same; and then everything was re-



Explicat Hippocratem , nec latum praterit vnguem;
Eloquio sectas, Thessalicosque mouet.
Nulla est cognitio, non experientia rerum,
Quam non attigerit, perpoliitque simul.

GALEN
(Claudius Galenus)



PARACELSUS

(Philippus Aureolus Paracelsus Theophrastus Bombastus von Hohenheim)

versed, the motions occurring, as it seemed, variously and confusedly together."

But with the perseverance that characterizes the work of true genius he gradually adduced the accurate explanation of all these complicated phenomena. First he showed that the contraction of the heart (systole) was exactly synchronous with the expansion (arterial diastole) of the great arteries at the root of the heart, and correctly stated that this was not because the arteries sucked air into their cavities, but because the heart forced its content of blood at an increased pressure into the circulatory channels. Then, with the background of the known fact (actually described by Vesalius) that the arteries terminate in the immediate neighborhood of the beginnings of the veins, he deduced and proved that the blood returns to the right auricle through venous paths. At times he uses the most ingenuous arguments.

"Now if the arteries are filled in the diastole with air then taken into them (a larger quantity of air penetrating when the pulse is large and full), it must come to pass that if you plunge into a bath of water or of oil when the pulse is strong and full, it ought forthwith to become either smaller or much slower, since the circumambient bath will render it either difficult or impossible for the air to penetrate. In like manner, as all the arteries, those that are deep-seated as well as those that are superficial, are dilated at the same instant and with the same rapidity, how is it possible that air should penetrate to the deeper parts as freely and quickly through the skin, flesh and other structures as through the cuticle alone?" Again, referring to the "pores" of Galen, he waxes vehement. "Still less is that opinion

to be tolerated which, as a two-fold material, one aerial, one sanguinous, is required for the composition of vital spirits, supposes the blood to ooze through the septum of the heart from the right to the left ventricle by certain hidden porosities, and the air to be attracted from the lungs through the great vessel, the pulmonary vein; and which, consequently, will have it that there are numerous porosities in the septum of the heart adapted for the transmission of the blood. But, by Hercules! no such pores can be demonstrated, nor in fact do any such exist. For the septum of the heart is of a denser and more compact structure than any portion of the body, except the bones and the sinews."

And so it runs throughout the whole essay. Step by step he takes the old concepts and refutes them with indisputable logic, confirmed by experiments which have served as models of their kind ever since. Like the other radical theories and discoveries we have mentioned, this of Harvey soon developed its champions and its enemies, but in keeping with the thoroughness of the man's work, the arguments used in refutation against him were, in general, short-lived and, like Pasteur, he enjoyed the keen delight of living to see the pride of his life's work accepted. The introduction of mathematical and physical sciences served to prepare the way for this acceptance, because after all it was essentially a problem of hydrodynamics. Respected and revered by his countrymen, Harvey presents a rare type of genius. He is described as an active, alert man of small stature, but of a dominating personality. He was known to have held Bacon in small esteem, and in this respect typifies an increasing spirit of his age—the absence of respect for authority in matters

of science. His entire work was by no means exact, but as the years have a habit of doing, they have served to wipe out that which was false and to preserve his great truth.

We are in the age of Harvey, Descartes, Van Helmont and Bacon. The works of the great Chancellor and Descartes had their intimate effect on the mode of thought of the times, and especially the mechanical philosophies of Descartes did much to direct the type of investigation of the men of medicine. Mechanical explanations were everywhere sought for in the solution of problems of disease. In natural evolution there appeared diverse systems of thought and new schools of medical doctrine. Especially prominent among the new "exact" sciences was that of chemistry. We have seen the impetus afforded by the work of Paracelsus, and this, together with the discoveries of Harvey, Galileo, Newton, Napier, Hooke (who invented the compound microscope—an instrument destined to change the whole science of medicine), and the doctrine of Jean Baptiste van Helmont (1577-1644), determined the important medical advances of this century. The last named man is of especial interest.

Van Helmont, the youngest son of a noble Flemish family, was born in Brussels in 1578. Of strictly Catholic education, obtained chiefly from his mother, he was at various times a Capuchin monk, a chemist, a mystic and a physician. He entered the University of Louvain as a young man, where, on graduation, he refused the degree of Master of Arts, saying he was "not even a disciple in any one of the seven liberal arts." With an insatiable lust for knowledge, he dabbled respectively in occultism, ethics, law, and finally, medicine. He was undoubtedly one of the

best informed men of his time, but apparently suffered from too deep a draught at "the Pierian spring," for with none of his studies was he satisfied and at times he himself describes dreams and fantasies occurring during moments of depression (and exaltation) which would afford delightful material for the theories of the modern alienist. He was an ardent disciple of Paracelsus, and like him believed that an "archeus" presided over each of the bodily functions (Van Helmont's term was "blas") and that these functions are effected only by means of a chemical change (due to the activity in each case of a fermentation or "gas"). He modified slightly the "archeus" of Paracelsus in that he held that the body was controlled by the "archeus influus," and that the organ of the soul and its various parts was controlled by the "archei insiti," which are subordinated to the "influus." Disease was caused by the "passions and perturbations of the archeus," and the efficacy of a drug depended upon its ability to appease the disturbing "idea" of the same archeus. An example which Withington quotes, for instance, is that dropsy is due, not to an organic lesion of the liver, but to the anger of the archeus of the kidney, who has lost his temper and refuses to work. One way of soothing him is to terrify him, and the best procedure to follow is to tie a snake about the patient's waist and to apply several living toads to the region of the kidneys!

Stripped of its impedimenta of fantastic language, however, Van Helmont's system of therapy was really a distinct advance over that, for instance, of Paracelsus. His researches into chemistry and physics added many to the type of drugs inaugurated by his German master, and the results of his work may

be clearly traced in the so-called iatrochemical and the iatrophysical schools—the two important schools of the century. The impelling principle back of the formation of these schools was the attempt to solve the mysteries of life and disease on a purely materialistic foundation, one of a chemical origin and the other on a physical basis. The name most prominently associated with the foundation of the chemical school was that of Francis de la Boe (Sylvius) (1614-1672), who was of French extraction, but who spent most of his life in Holland, where he was professor of medicine at Leyden for fourteen years. His early statements were impressive—"Nothing is to be admitted as true in medicine or natural science unless experience has confirmed or shown it to be true." He further describes this "experience" as (1) anatomical, (2) chemical, and (3) clinical; he adds a stern admonition then to beware of mere opinions and to build all important concepts on the basis of anatomy, chemistry, and Harvey's doctrine of the circulation of the blood (he was one of the stoutest champions of the truth of Harvey's discovery). Sylvius, who has been called the "last of the Galenists," made a final effort to reestablish the humoral doctrine, admixed with a remarkable background of chemical ideas. To him, fermentation (Van Helmont's "gases") played an important role in the vital processes. Chemical disturbances of these processes (acridities) were the cause of fevers and various other forms of disease. In his writing we find a curious blending of humoral, "archaic" and chemical terms. His most notable service to medicine was his unswerving belief in the "ultimate identity" of organic and inorganic processes in chemistry. He was also a teacher of signal

ability and wide repute. His devotion to this art may be seen in his words (from Daremberg): "I have led my pupils by the hand to medical practice, using a method unknown at Leyden, or perhaps elsewhere, i. e., taking them daily to visit the sick at the public hospital. There I have put the symptoms of disease before their eyes; have let them hear the complaints of the patients, and have asked them their opinions as to the causes and rational treatment of each case, and the reasons for those opinions. Then I have given my own judgment on every point. Together with me they have seen the happy results of treatment when God has granted to our cares a restoration of health; or they have assisted in examining the body when the patient has paid the inevitable tribute to death."

As the name implies, the iatrophysical school (by some called iatromechanical and iatromathematical) laid its foundation on a basis of mechanical explanation of life and disease. Again it is well to remember that we are considering an intensely materialistic and ultrascientific period. Many of the most prominent churchmen were mathematicians. Amazing discoveries were "scarcely off the press" before a modification or a new application or, more often, a new discovery attracted the minds and efforts of scientific men. Hence it is not surprising to find a larger and more active group of men associated with this school than with the iatrochemical. The founder of the former is generally held to be Borelli, but one of the most important and prominent of its exponents was the Italian Santoro Santorius, professor at Padua and a close friend of the great Galileo. He became famous through an attempt to determine the "insensible perspiration,"

amazing the world as well as himself by discovering that this loss exceeds in amount all the other excretions of the body combined! This result he obtained by devising a "weighing-chair," or as it was called, "steelyard," in which, according to some historians, he spent much of his life. He experimented with diaphoretics (sweat-producing drugs), diets, and various skin applications. He greatly overestimated the value of his results, but indirectly he introduced an immense amount of valuable data with reference to the hygiene of the skin, the significance of changes in weight, and the value of a regular, balanced diet. The nicety of his measurements was extreme and they surpass anything of their kind in physiologic experimentation up to his time. He is also credited with the invention of several useful instruments, and used the "air and water" thermometer of Galileo for clinical purposes.

The first man who seriously attempted to explain the "problems of life and disease" on a physical basis was Giovanni Alfonso Borelli (1608-1679), of Naples, whose work *De motu animalium*, published in 1680, is held by many to mark an epoch second only to that made by the publication of Harvey's immortal discovery. In this work, a great many of the hazy ideas which were left over from the theorizings of Paracelsus and Van Helmont received their proper coat of paint, and became matters of established fact. Most important among these were (1) the proof of the mechanical action of the muscles (Borelli showed beautifully that the acts of walking, lifting, swimming, flying, climbing, etc., were mechanical processes, brought about by the lever action of the muscles, and that the forces exerted were measurable and, in each case, separable

into their component parts); (2) the proper interpretation of the grinding action of the walls of the stomach, and (3) that nutrition and secretion were shown to be dependent upon the tension (?) of the vessels. (The last named idea was a rather premature attempt on the part of Borelli to demonstrate the relation of the blood flow to the secretory action of certain of the glands.)

These suffice to show us the basis of the attempt made by adherents of this school to place all the mechanisms of the human body on a purely mechanical and measurable foundation. Among the disciples of the idea were some of the ablest men of the day, but there arose a man in England who was destined to so far surpass any of the iatrophysicists as to make the school and its too finely applied ideas unnecessary and useless. What seems of greatest significance about this new Englishman is that he was a clinician, devoting his time and activities almost entirely to the problems of internal medicine.

Thomas Sydenham (1624-1689), born in an English family of long British lineage, received his early degree at Oxford, and his degree of Doctor of Medicine at Montpellier. He became a fair chemist, knew little or at least spoke little of his knowledge of anatomy, and has been repeatedly eulogized for his conduct, good humor and his sound, humanistic, scientific principles. As his model in the study of disease, he would have no other than Hippocrates. He again studied the "natural history of disease," and so pointedly and repeatedly referred to the "father of medicine" that he was, not without reason, often termed "the English Hippocrates." Both the iatrochemists and the iatrophysicists he cast aside with a supreme in-

difference, and entered the lists of medicine with the avowed purpose of avoiding, and even suppressing, the hundreds of theoretical disputes which were engaging the men of his time on the Continent. He embodies splendidly those admirable English qualities of broadness of mind and the capability of prolonged and concentrated effort (he was a cavalry officer in the civil wars), and well merited the tributes paid him by so many compatriot commentators. He approached the modern conception of all pathologic reactions when he held that disease is nothing more than an effort of nature to restore the health of the patient "by the elimination of the morbid matter." And not only in theory did this great Anglo-Saxon excel. His regimen of treatment is at once the result of the patient thought of a logical mind, and the product of the sanest kind of clinical observation. Like Hippocrates of old, he believed that the place of the internist was at the bedside of the patient and, also like the great master, his kindly regard for the man or woman in the sick room were bound up with the highest ethical standards.

Such a man could never live without marked influence on the times and Sydenham's fame soon spread. His success as a clinician and an internist was great—in an age of scientific disputes his active sympathetic personality could not be otherwise. What particularly impressed his contemporaries was his abolition of the old ideas of treating fevers by purgation and sweating, and in their place using the sounder principle of cooling the surface (as well as the interior, so far as the latter was possible by drinks) of the body of the patient with water and air. He is also famous for his favorite doctrine of

the "epidemic constitution," which in reality is also a product of the theories and teachings of Hippocrates. Sydenham held that epidemic diseases, while, of course, differing from each other in many important characteristics, still presented a common point of similarity. This, he says, is the "type" which, while it may change at different times, varies only because of "certain secret and inexplicable changes in the bowels of the earth." However, like the great Greek whom Sydenham so consistently emulated, he must needs make his mistakes, and it is not for us to link them with his life and his work. He gave us enough of the soundest kind of medical observations to perpetuate his name along with the lamentably few of his equals. Among the masterpieces of all time stand a few of Sydenham's descriptions of diseases, notably those of chorea (one form still bears his name) and gout. His glossary of therapeutics was as unpretentious as his ideas of disease when compared to the schools of his time, and his *Processus integri*, published in 1692, became the standard book of its kind throughout the eighteenth century.

Inseparably linked with the name of Thomas Sydenham, stands that of his friend John Locke, the great "sensational philosopher." The latter was thoroughly trained in medicine and many of its corollary branches, and like Aristotle, practiced in an amateur sort of way on a few private patients. Many are inclined to attribute the thoroughness of the style of Sydenham to his famous friend, and in many respects the latter must have influenced the fine practicality of the Hippocrates of England. An extract from a letter written by Locke to W. Molyneux expresses succinctly his philosophy of

therapeusis. "You cannot imagine how far a little observation carefully made by a man not tied up to the four humours (Galen), or sal, sulphur, and mercury (Paracelsus), or to acid and alkali (Sylvius and Willis), which has of late prevailed, will carry a man in the curing of diseases though very stubborn and dangerous; and that with very little and common things, and almost no medicine at all." (J. F. Payne). Dr. Oliver Wendell Holmes improved only in diction on this when in 1860 he warned his colleagues of the Massachusetts Medical Society, stating in his inimitable style: "I will venture to say this, that if every specific were to fail utterly, if the cinchona trees all died out, and the arsenic mines were exhausted, and the sulphur regions were burned up, if every drug from the vegetable, animal and mineral kingdom were to disappear from the market, a body of enlightened men organized as a distinct profession would be required just as much as now, and respected and trusted as now, whose province should be to guard against the causes of disease, to eliminate them if possible when still present, to order all the conditions of the patient so as to favor the efforts of the system to right itself, and to give those predictions of the course of disease which only experience can warrant, and which in so many cases relieve the exaggerated fears of sufferers and their friends, or warn them in season of impending danger. Great as the loss would be if certain active remedies could no longer be obtained, it would leave the medical profession the most essential part of its duties" Over all physicians since the Golden Age of Greece has hung this admonition; great men have repeated it in their own words at different times, and still

the charlatan with his "gunshot prescriptions," still "healers" with their faith cures, and still the pernicious quack with his "venereal guarantee" thrive in our midst, protected ethically by tied hands, and by a blind legality. Verily, history repeats itself.

Chief among the men impressed by Sydenham and Locke and their doctrine were Boerhaave (1668-1738) of Leyden, and Baglivi (1669-1707) of Italy. The former, one of Sydenham's pupils, enjoyed the reputation of being the greatest medical teacher in all Europe during his active days. Nor was his fame limited by Continental boundaries. America and South America sent their devotees to the shrine at Leyden, and he is said to have received a letter from an inquirer in China, addressed to "Boerhaave in Europe." He emphasized in a peculiarly valuable way the scientific value of medicine, tolerating not at all the many vague theories of his day, and basing his philosophy of medicine on physiologic processes. He stated that the body was composed of solids "in the shape of fibers and vessels, and of fluids contained in the latter, and acted upon them according to the laws of hydrostatics." True, he did not furnish us with a much better system of medical reasoning than did those men whom he condemned, and, as Garrison says, "he is remembered as a great teacher and especially as a chemist." The latter fact seems to rest chiefly on the fact that he devised an improved method for making vinegar. His philosophy may be best summed up in his words: "Every vital action depends on certain bodily conditions and relations; every change in these bodily conditions and relations is necessarily followed by a corresponding change in the vital activity;

medicine, therefore, must be based upon physiology." It was the elaboration and application of this doctrine for which his famous pupil Von Haller did so much during the eighteenth century. Two others of his pupils may also be mentioned, Van Swieten and De Haen, who became the founders of the so-called "Old Vienna School," and the latter of whom served as a sort of Boswell to Boerhaave's Johnson.

Baglivi, the other of the two most prominent pupils of Thomas Sydenham, was a different manner of man. He studied first at Naples, and is alleged to have received a degree at the old University of Salerno, which at this time must have lost much of its former glory. He later spent a deal of time traveling in Italy, tarrying at Bologna to sit at the feet of the great Malpighi, who at that time occupied a position of preeminence among the anatomists of Europe, and finally at the conclusion of his wanderings published his *Praxis Medica* and became professor of anatomy at Rome. He lived but a short time (thirty-eight years), possibly as a result of the intensive type of work to which he applied himself in the university. He was an active teacher, lecturing, it is said, twice daily to his anatomy classes, besides conducting classes in chemistry and medicine. He was one of the bright stars of the medical firmament. His experimental physiology ranks with that of the masters, and it is said to have been his custom before retiring each night to detail in writing the exact condition of each of his numerous patients. Here another physician sounded the ever-increasing alarm of the dangers and futility of useless drugging of sick people, and strongly advised an

expectant form of treatment. Like Hippocrates he held that the ability to tell what will become of a patient (prognosis) is better than "to be able to give a name to the disorder" (Withington). In other words, he carried the broad principles of Sydenham to Italy, followed and taught them the brief time allotted him to live, and gained his well deserved "place in the sun" by virtue of his courageous simplicity.

Thus with the internists. Surgery, on the other hand, was still in the throes of a battle for its possession between physicians, surgeons, barbers and many of the miserable charlatans who had survived the type of the sixteenth century. Consequently it was a less progressive art. No Paré appeared, nor indeed did anyone worthy of comparison to the great Frenchman. It was largely an age of bloodletting and chicanery. The former is only distinguished from the latter because of a few sober-minded souls who at least did not retrograde in this branch of medicine. Of such were Richard Wiseman (1622-1676) of England, who first described "white swelling" of joints as a tuberculous condition, and compared with Sydenham as a leader in founding the surgery of England. In Germany the leading surgeon was Wilhelm Fabry (Fabricius Hildanus) (1560-1624), a man of bold ingenuity at the operating table and of conservative good sense at the bedside. His "Century of Surgical Cases," the result of forty years of observation and experience, is a splendid collection of case descriptions of rare value. In common with his contemporaries Scultetus (1595-1645) and Matthæus Purmann (1649-1711) he believed that the best way to treat a wound made by a sharp instrument (sword, spear, dirk,

etc.) was to anoint the weapon itself with the so-called "weapon salve," rather than to treat the wound as if it were infected, and demanded remedial measures locally applied such as Paré had used. Of the Italians, only Peter Marchetti (1589-1675), professor of surgery at Padua, and Marcus Aurelius Severinus (1580-1656), need be mentioned. The former was a skillful operator and patterned his work and much of his theory after Ambroise Paré. He performed most of the abdominal operations which are done to-day, sutured cut tendons (a procedure not attempted by his contemporaries), made trephine openings in the skull and like many of his time, had learned to amputate above the diseased part. Severinus was in charge of a hospital for incurables at Naples where he earned a wide reputation as a surgeon.

Some interesting facts may be related concerning the obstetrics of the period. Following Paré with his readoption of podalic version, there was no one of consequence up to the time of François Moriceau (1637-1709), of Paris, whose name is now associated with an obstetric maneuver used in extracting the after-coming head in breech deliveries. In England there had lived a family by the name of Chamberlen, in which at least one male member of each generation had been a physician. One of them late in the sixteenth century devised the obstetrical forceps, and, maintaining it as a family secret, handed it down to succeeding generations. In this manner it was kept as a family secret for four generations. The Chamberlens claimed that by this means they could deliver any woman of a live baby, without injury to the mother. Heretofore, the method revived by Paré (version) had been the only

method by which rapid delivery could be effected, and the success of the Chamberlens was naturally great. Hugh Chamberlen (1630-1706), being forced to leave England on account of some political difficulties into which he had gotten himself, approached Moriceau and offered to sell the family secret for the sum of 10,000 livres. The French obstetrician archly placed a rachitic dwarf at the disposal of Hugh Chamberlen and requested a demonstration. After several hours of vain attempt the latter confessed himself beaten (the passage of a fair-sized child through a badly contracted rachitic pelvis is often totally impossible). Williams states that friendly relations were maintained, however, between the two, and some time later Chamberlen translated his (Moriceau's) work on the diseases of pregnant and puerperal women (1668) into English.

Hugh the younger (1664-1728) gradually permitted the secret of the forceps to become the common property of the profession. Moriceau was the first to write accurate accounts of many obstetric phenomena which are now commonly recognized, especially important being those of the separation of the pelvic bones during labor, extra-uterine pregnancy, and epidemic puerperal fever. In Holland, Van Deventer and Hendrik Roonhuyze became famous. The former has been called the father of modern obstetrics, chiefly on account of his priority in describing for the first time the pelvis and its common deformities which complicate labor. The latter was more of a surgeon than an obstetrician, and on several occasions performed Cæsarian section successfully. His gynecological operations were the first of their kind and served as a pattern

for the modern operative procedure of this important branch.

In reviewing the status of medicine in the seventeenth century, we are impressed with the fact that a few great foundations were laid. Physiology was launched as a dynamic science. Furthermore, the discovery of Harvey served to stimulate accurate understanding of the various other branches. Anatomy and dissection had become a unit in practically every medical curriculum of the Continent and England. Indirectly, chemistry and physics were adding their quota to the known facts concerning the treatment of disease. Sydenham enriched the doctrine of medicine with a method which, though it was accompanied with little or no discoveries of any value, reestablished the gift of Hippocrates where it belonged, i. e., at the head of the modes of treatment. Quackery, professional poisoning, and even superstition were distressingly widespread. Fees of physician, midwife and especially apothecary were at times enormous. As a doctrine, medicine was established on a splendid basis; as a profession, it was a lamentable affair. The American colonies drew their quota of European medical men, and it was not long before medicine was being "read" in the New World. This custom was established early, and has continued up to within the days of the training of some of the oldest of the present-day physicians. Frontier medicine was naturally of the most practical sort. America received its first hospital from Cortez, in Mexico; the colonies, in Manhattan Island in 1663.

It had become the habit to reject theories unless they had substantial proof. The spirit of inquiry

permeated every vital problem. Witchcraft was being prepared for, but it must have been a more comfortable thing to be sick during the seventeenth century than during the preceding hundred years! Dogma still claimed its short-sighted champions, but the tyranny of mere authority in medicine was forever overthrown.

CHAPTER V

MEDICINE IN THE EIGHTEENTH CENTURY

HISTORIANS in general agree that the great characterizing features of eighteenth-century medicine is the tendency to theorize, methodize and to formulate "systems" by which every phenomenon of physiology, medicine, therapy and pathology could be catalogued and explained. We have seen the rise and fall of the iatromechanical school and its less viable brother, the iatrochemical school. A glimpse at least has been given of the doctrines of Sydenham and Locke, Boerhaave (who more properly belongs to the eighteenth century), and Baglivi, and Fabricius, and Scultetus. This inveterate tendency to pigeonhole facts, to give an inviolable law to all phenomena, "to give things a name" by which the things themselves and all their characteristics may be known and understood, has always been a sort of evil genius of medicine. Plato, Galen, Paracelsus, and Borelli had fallen into this form of error, and even to-day we are far from free from this desire to simplify an elaborate and complicated science by the adoption of a "classification" of diseases, drugs and modes of treatment. This seems especially true in the vast unexplored field of mental diseases. However, it seems to have been the fault of the remarkable series of observations and discoveries in physics and chemistry during the seventeenth and

eighteenth centuries, that all scientists should seek to theorize on the cause and nature of the heart-beat much as they did about the interaction between muriatic acid and caustic potash! Despite the fact of the life and work of men like Jenner, John Hunter, and Morgagni, there was an overwhelming desire on the part of most physicians to turn medicine into a mathematical doctrine.

First, if not foremost, among these theorists was Karl von Linné or Linnæus (1707-1778), a botanist of Sweden, who, it is said, studied medicine in order to win the daughter of a prominent physician. His greatest offense occurred in the field of botany, when he classified plants according to characteristics of the stamens and pistils (the sexual organs of flowers). The offense lay not so much in the grounds of the classification as in the fact that he drew far too much attention to the flower, and gave little or none to the plant. It was this man who originated the so-called binomial nomenclature (each organism was given a generic or family name and a specific or given name), an instrument of incalculable value, used to the exclusion of all others in the botanical and zoölogical sciences of to-day.

Early in this century there arose the "animists." George Ernst Stahl (1660-1734), a Bavarian, denied that chemistry had anything to do with medicine, and revived the idea that "the source of all vital movement is nothing else than the soul, which builds up the machine of the body, and maintains it for a time against external influences." For this reason, chemistry and anatomy were discarded by this eccentric genius, who humbly believed that "the soul, in spite of its mistakes, knows much more about the body it has built up than does the

most skilful physician." Of a necessity, his therapeutic system surpassed in simplicity even that of Hippocrates, consisting chiefly of bloodletting, purgation and the forcing of large amounts of water. It is said that in his old age he gave even these simple remedies up, rejected the use of quinine and opium, resorting finally to "dosing all his patients with salt and water, which could not do much harm, and might help to counteract putrefaction." For more than twenty years, during which he was professor of medicine at Halle, he adopted this means of opposing materialism. The "nature" of Sydenham and the archeus of Van Helmont are both recalled to mind in perusing this hazy philosophy of Stahl. Fortunately, neither in his own time nor since, did the "animist" theory gain wide credence.

A contemporary, and colleague of Stahl at Halle, was Friedrich Hoffmann (1660-1742). He too fell under the temptation, and added another ponderous theory, differing greatly from that of Stahl, but none the less speculative on that account. He assumed that life in all its forms depended upon a universally diffused "ether," breathed in by members of the animal kingdom, absorbed into the blood, accumulated in the brain and there formed into the "pneuma" or "nervous fluid." He vainly attempted in this way to reconcile the spiritual and materialistic views of nature, and on this doctrine sought to explain all the phenomena of life, death and disease. This nervous fluid served, according to its originator, to act through the nervous system upon all structures of the body, keeping them in "tone" or permitting them to become "lax," dependent upon the objective condition of the body,

and in acute disease caused a spasm of the musculature of the affected part, while in chronic diseases a corresponding flaccidity existed. Of value, however, were his descriptions of chlorosis (a form of secondary anemia) and German measles. His "system" likewise soon lapsed into "innocuous desuetude."

A third school was responsible for the term "organicists." This group, in common with the two we have just discussed, believed that the activities of living organisms could not be satisfactorily explained by the laws of chemistry and physics, but differed from them in ascribing these activities to an endogenous origin rather than to a "soul" or "ether" from without, and they held that life "results from the intimate structure of the body itself." Francis Glisson, Regius Professor of Medicine at Cambridge, has been credited with the origin of the "doctrine of irritability," and it is from this that the organic group undoubtedly obtained their inspiration. Glisson's name is handed down to us in connection with a structure of the liver (its capsule) which he first accurately described. He also observed what he thought to be a characteristic of all living tissue—i. e., that it responded to a stimulus in a given way. This feature he spoke of as "irritability" and made it practically synonymous with the word life. It invested all tissues and was separable from the body at death. He had some difficulty in reconciling the phenomena as they occurred both in man and in beast, but avoided further dispute by stating that in human bodies, the irritability was produced by virtue of a "semi-material" substance, which after death became an angel. This theory had long been forgotten, until

partially revived by one of the greatest figures in the history of medicine.

Albrecht von Haller was born in 1708 of Swiss parents. Many are the stories of the prodigious attainments of his youth, and after a meteoric career as a student at the University of Leyden under Boerhaave, he went to Göttingen, where he occupied a position comparable to that of his master, devoting his life to the most varied sort of interests, and teaching a large number of medical students. He had made decidedly valuable contributions to every branch of medicine. He was widely famous as a poet and a botanist, and is said to have written, while at Göttingen, "some 1,300 scientific papers." His knowledge of the literature of medicine and the allied sciences was probably never equaled, and he "was the founder of scientific bibliography." He was an eminent anatomist and physiologist, and by many is held to be the greatest physician in the eighteenth century. So far as his doctrine is concerned, it is registered in his papers "On the Sentient and Irritable Parts of Animals," read before the Royal Society of Göttingen in 1752. In these, he states that animal structures may be divided into "irritable, sentient and neutral." Like Glisson, he held that the "irritability" (no doubt arrived at in his prolific physiologic experimentation) is the principal manifestation of life, and is inseparable from it, excepting for a short time after the death of the body when the parts are still subject to the reaction to certain stimuli. This, indirectly, furnishes us with the evidence of his greatest contribution to the science of physiology—i. e., the laboratory demonstration of the phenomenon of the irritability of muscle. In spite of a heckling opposi-

tion which almost immediately sprang up throughout Europe and England, Haller stoutly maintained his doctrine, and what is doubly important, took the stand that all such theories and systems should be founded on experiment. In the light of the knowledge of his time, backed up by his delicate laboratory proofs, small wonder that his position was unshakable. The misfortune was that it only seemed to lead to the formulation of less objectionable theories on the part of many of his contemporaries and a few of his followers. Among the latter may be mentioned John Brown (1735-88) and William Cullen (1712-90). The latter was professor of medicine at Edinburgh, where he earned an eminence and enjoyed a popularity of the highest kind. He, like Haller, based his system of medicine on the "irritability" theory of Glisson, but elaborated enough to include all pathological conditions under the doctrine in his "First Lines of the Practice of Physic" and especially in the "Nosology or Classification of Diseases." It was nearly as ponderous and complex as the writings of Galen or Avicenna, but during a brief life was reprinted a number of times.

After Haller came the physiologists Stephen Hales (1677-1761), an English clergyman who devised the first instrument for measuring the blood pressure, René A. F. de Réaumur (1683-1757), and Lazaro Spallanzani, an Italian priest of splendid ability. In England also appeared William Hewson (1739-74), a pupil of John Hunter, who approached the modern concept of the phenomenon of the coagulation of blood, and Scotland furnished, through Joseph Black (1728-99), the greatest physiological discovery of the century—that of the physiology of

the respiration, which, as Garrison points out, hinged upon the attendant discoveries by Cavendish, Rutherford, Priestley and Lavoisier, of hydrogen, nitrogen, and oxygen as constituents of the air.

The last of the great "systematizers of medicine" was John Brown, who literally set Europe afire with his so-called Brunonian system. He modified the theory of "irritability" in that he held that "life is a forced state produced by the action of stimuli on the 'excitability' of the body." The "exciting powers" are (1) external, such as warmth, food, muscular motion, etc., and (2) internal, such as the senses, passions and the internal functions. "All exciting powers are stimulant, the apparent debilitating or sedative effect of some being due to a deficiency in the degree of stimulus." He professed disease to be "sthénic" or "asthénic," and concluded that at least 97 per cent of all diseases came under the latter class, and that on this account should receive a "stimulating" treatment. Diagnosis required merely the answer to three questions. 1. Is the disease general or local? 2. Is it sthénic or asthénic? 3. What is its degree? Once these answers were ascertained, the treatment became simply the application of a "stimulus" of the proper type and degree. For instance, it is said that when his son became ill with measles, he stripped the youth nearly naked, gave him a fluid diet, and let him do otherwise about as he pleased. Needless to say, the lad rapidly recovered. The man must be granted the elements of brilliance. He recognized that certain symptoms, such as convulsions, fainting, delirium and the like, which since Galen had been held to indicate the presence of inflammation, were in reality merely the manifestations of weakness. His

system surpassed even that of Hippocrates in simplicity and applicability, but was woefully lacking in comparison with the Greek doctrine, in being founded on sound observation. The world had had sixteen centuries of theorizing and speculative philosophies. Fortunately it shortly rejected the Brunonian craze, which none the less at one time threatened to supplant everything of its kind on the Continent, and as late as 1802 caused a pitched battle between Brunonian and non-Brunonian students, which required the interference of the military in its subjugation. With the exception of France and England (the prophet's honor) the doctrine was, for a time, widely accepted. Italy, Germany, and even the distant shores of America enthusiastically embraced the new and simple system, but after twenty-five years it was almost never heard of. The author himself died of the effects of the drugs at either end of his "stimulative" list—alcohol and opium, and with him perished, let us hope, the last attempt to systematize medicine along the line of the "bees and other bugs" of zoölogical nomenclature.

It is with a measure of relief and pleasure that we turn to the consideration of the surgery of the eighteenth century, and review the triumphal march of chirurgical events culminating in the appearance of "The Queen's Hunter." Here, in contrast to the vapid imaginings of the internists, we find real progress. In France and in England, in contrast to the monopoly formerly held by Italy, the social and professional standards of the surgeon were unfurled in the front rank of the army of medicine. Jean-Louis Petit (1674-1750) and his pupil Dominique Anel (1678-1725) form the French nucleus of surgery of the early part of the century. The

former of these was probably the foremost surgeon of the time, and invented the screw tourniquet which still bears his name. He is alleged to have performed the first mastoid operation, and drew attention to the necessity of removing glands in the vicinity of cancer. His pupil, Anel, was a much older man than the master, and reminds us of Paré in two respects. He gained much of his experience on the field of battle, and he again called attention to the efficacy of the ligature, using it, in one instance, in curing an aneurism on a monk in Rome in the year 1710. Only three years later, he is said to have passed a minute probe through the tear duct, and later in the same year, devised a syringe with which he could inject the tear sac itself. Anel was a stern opponent of the "blood suckers" of the age, whose trick in trade was to suck the wounds of the soldiers and, after muttering a few incantations, smear on a little oil, and cover the whole with a cross-shaped bandage. Within the lifetime of this famous army surgeon, the revolting and dangerous "wound suckers," of whom there had been many, on account of the dearth of trained surgeons, were reduced to a paltry few who practiced their art on the sly.

These two surgeons were both located at the Royal Academy of Surgery, which had recently been founded in France, and which served throughout this century as the center of French chirurgy. One of its most eminent members was Pierre Desault (1744-95), who devised the method of bandaging the arm and shoulder in fracture of the collar bone which bears his name. He also developed the procedure of tying off blood vessels in the treatment of aneurism (a device almost forgotten since the

time of Celsus and Antyllus), and is chiefly remembered for his splendid work in advancing the art of teaching surgery, a practice which had been sadly neglected during the preceding seventeen centuries.

But it is to England that we must turn for one of the greatest chapters in the history of surgical progress. It opens with the name of William Cheselden (1688-1752), who became chief surgeon to St. Thomas' Hospital in 1723. This big-hearted, kindly man, appearing in his portrait a typical heir to the "serenity of the stout," nevertheless gained fame for performing an operation for the removal of stone (lithotomy) in fifty-four seconds, with, we are told, a mortality of only seven per cent! Truly a wonderful performance in the pre-anesthetic and pre-antiseptic days. Then follow Charles White (1728-1813) of Manchester, who was the pioneer in aseptic obstetrics, long before O. W. Holmes and Semmelweis and Percival Pott (1714-1788) of London. The latter, while in London, fell one day in the street, and sustained that commonest fracture of the lower leg, to which his name has ever since been affixed (a fracture just above the ankle, with an outward dislocation of the foot). He produced between the years 1756 and 1779, treatises on hernia, fractures, and especially on the deformities and sequelæ resulting from caries (now, but not by Pott, known to be due to tuberculosis of the bone) of the spine. These works are among the classics of English surgery, and would serve to perpetuate his name even though the terms "Pott's fracture" and "Pott's disease" (tuberculosis of the spine) were not so widely used.

William Hunter (1718-1783), though more properly an obstetrician, had best be mentioned here as

a means of introduction to his brother John Hunter, the greatest surgeon in the world during the eighteenth century, and one of the three greatest of history. William was trained at Glasgow, and migrating to London soon became the foremost figure in his profession in that city. His portrait and his life are those of a refined and cultured gentleman. His best work was the result of thirty years of arduous labor, the "Atlas of the Pregnant Uterus." His diverse interests are manifested in his publications on fractures, jurisprudence and anatomic history. It is recorded that he was strongly opposed to the use of obstetric forceps, which, since the cupidity of the Chamberlen family had been mastered, had been used by obstetricians of England and the Continent.

To this ennobling figure came, in 1748, his brother John (1728-1793), at that time little more than a vagrant Scotch boy, "fonder of taverns and theater galleries than of book learning." Under the magically instructive influence of the older man, the "idle, heedless and aimless" mind of John Hunter found itself, so that by his second winter in London, William had given him charge of his practical class in dissecting. From then on, despite his lack of liberal education, his career was phenomenal. He early devoted himself to physiological and anatomical research, and his contributions vie in worth to those of Haller and Harvey, founded, like them, on accurate experimental data. Scholastic training seemed superfluous to his native genius. Late in life, he wrote of an enemy: "Jesse Foot accuses me of not understanding the dead languages; but I could teach him that on the dead body which he never knew in any language dead or living," but

nevertheless, such pursuits would possibly have served to remedy one of his two greatest defects—a difficulty in expressing the abstract ideas demanded by his prolific discoveries, and an ungovernable temper. In 1761 he joined in Hodgson and Keppel's expedition to Belle Isle as staff surgeon and here gained his experience in gunshot wounds formulated in his work on that subject which was printed in 1794. He returned to London in 1763 and began his career as a London surgeon, at the same time being engaged in teaching anatomy, and in ardent experimental investigation. In 1768 he was elected a surgeon to St. George's Hospital and later, a member of the Corporation of Surgeons. Among the house pupils whom he then began to take was Edward Jenner, who until Hunter's fateful end maintained a correspondence of close friendship with his master. Others of his pupils were Abernethy, Coleman, Astley Cooper, Macartney and Thomas Young.

The blackest mark possible of registration against this great man is due to the quarrel with his brother. In 1780 John Hunter read before the Royal Society a paper claiming priority of the discovery of the uteroplacental circulation (the interchange of blood between the child and the pregnant mother). William, in the work we have mentioned, had described the same thing, and wrote to the Society, claiming the distinction, which he justly deserved. This bit of thievery engendered an estrangement which lasted until the death of William Hunter three years later, when, in tears, the younger brother effected a death-bed reconciliation. Hunter, in personality, was open-countenanced, yet rugged, of a hasty and impetuous nature, and taciturn to a degree. He was

of short stature, but with his reddish-yellow hair and beetling brows was a commanding figure of a man, honored and loved by his pupils, placated and respected by his friends, and bitterly hated by a few enemies. During a meeting of his colleagues of St. George's Hospital, whereat he attempted to intercede in behalf of some students who had not the necessary requirements for matriculation, a heckling confrère flatly contradicted him, and his resultant anger brought on one of the attacks from which he had long been a sufferer (angina pectoris). A few minutes later he "whose range of thought nature alone could fill" was dead, in literal fulfillment of his own prophecy: "My life is in the hands of any rascal who chooses to annoy and tease me." In 1859, the remains of his body were removed from St. Martin's-in-the-Fields to Islip's chapel in Westminster Abbey, where they now rest close to those of Ben Jonson.

Enumeration of his contributions to the science of medicine shows a list of remarkably original investigations, diligent labors, and usually logical deductions. His experiments range from the transplantation of a cockspur to his personal experience with syphilis, with which he became accidentally infected, and which he permitted for a while to go untreated in order that he might study the condition in his own person. His home in Leicester Fields was a veritable zoölogical garden filled with bees, beetles, hedgehogs (similar to those which he commended to the attention of Edward Jenner, when the latter failed to prosper in his first love affair), leopards, fish, and in fact any member of the animal kingdom on which he might by the most devious ways imaginable lay his finger. He poisoned, as he states, "some thousands of animals," inserted shot

into the bones of pigs, was nearly killed during some experiments on his leopards, and, like Dr. Pott and his fracture, gave his undivided attention for a while to the process of tendon repair, when he hurt one of the ligaments of his own leg while dancing. No phenomenon of animal life would have escaped his rapacious search for truth had his life been long enough. His four masterpieces typify his manifold interests. They are the "Natural History of the Human Teeth" (1771); "Venereal Disease" (1786); "Observations on Certain Parts of the Animal Economy" (1786) and the "Treatise on the Blood, Inflammation and Gunshot Wounds" (1794). His eminence as a surgeon rests chiefly with the fact that he recognized the anatomical and pathological reasons for tying off arteries well above the diseased portion (in the famous case it was a traumatic aneurism behind the knee), knowing from his experiments on the antlers of a deer in the gardens of Richmond Park that a collateral circulation would be rapidly established to provide blood for the parts which had been supplied by the tied artery. In this sense he is the founder of surgical pathology, and occupies a place of the highest distinction in the annals of comparative physiology. Another of his prophetic sayings has held true. "When I am dead," he once stated to Dr. Garthshore, "you will not soon meet with another John Hunter."

No less important, but somewhat less meteoric was the career of Hunter's pupil, Thomas Young (1773-1829), who conjointly with Helmholtz propagated a theory of color vision which is to be found in all modern textbooks of physiology. He was probably the most highly educated physician of the age in spite of such men as Haller, William Hunter



ANDREAS VESALIUS BRUXELLENSIS
ANATOMICORVM FACILE PRINCEPS

*Corporis humani qui membra minut secaret
Vesalio nullus doctior extiterat.*

*Hic Medicis auxit & artem,
Dum subit internas qua satuere vias*

ANDREAS VESALIUS



OPERATION FOR THE STONE, PERFORMED ON A PRISONER OF LOUIS XI
IN ST. SEVERIN CEMETERY, 1474

and Heberden, and vies with John Hunter in the versatility of his accomplishments in science. His important and valuable work was done in the field of optics, including surgery of the eye, but he is only slightly less noted for his reports on consumption, the wave theory of light, the theory of the tides, Egyptology and his doctrine of energy. By Tscherning he was considered the "father of physiologic optics"; by Helmholtz, "one of the most clear-sighted men who ever lived," and by Garrison, who has given us a discriminating connoisseur's impression of nearly all of the portraits of physicians he has been able to gather, as "probably the handsomest of all great physicians."

The closing years of the eighteenth century are so filled with masses of names, discoveries, theories, and accomplishments in the field of medicine, that they cannot all be adequately treated in a work of this kind with justice to each. On this account we will only consider those names and those works from which have evolved the great ideas of modern medicine. Although Haller showed during this century that most medical doctrines, and indeed the broad abstract idea of medicine itself, were the product of numerous ages and numerous men, that only a rare few may wear the crown of Hippocrates, Paré, Harvey and Hunter, nevertheless important and original discoveries were made in this and the next century, and with each of them was taken a step forward in the path of medicine by men who merit our attention. Such a man was Giovanni Morgagni (1682-1771), who, when nearly seventy years old, published the results of a long life actively applied, chiefly as professor of medicine at Padua. This work, "The Seats and Causes of Disease, Investigated by

Anatomy," comprises a series of letters describing for the first time the correlated findings of the clinician at the bedside, and the pathologist at the autopsy table, of a large number of cases. Bonnet, Tulp, Valsalva, Haller, and Lancisi had made observations of post-mortem findings, but to Morgagni must be given the credit of originating the clinical-pathological association of disease, and of raising the science of pathologic anatomy to the dignity which it now possesses. He cleared up forever the hazy conception of the difference between the terms "lesion" and disease, especially with regard to the heart. He described tuberculosis of the kidney, syphilitic aneurism, and after his epoch-making work nothing more was heard of the only remaining legacy of Hippocrates which worked harm—the humoral concept. The whole medical world was quick to grasp at the value of the work of this modest Italian, and indeed to-day medical schools which deserve the name of such follow his innovation in comparing the case history with the results of the necropsy, not seldom to the discomfiture of the clinician, but always to the advantage of the student of truth.

In the same year during which Morgagni's five books of letters were published there appeared a modest pamphlet by Leopold Auenbrugger (1722-1809), which was destined to influence the history of medicine fully as much, if not more, than the ponderous volumes from Italy. This brochure, entitled "A New Invention for Discovering Obscure Thoracic Diseases by Percussion of the Chest," describes a beautifully original bit of work, and in conjunction with the art of auscultation described by Laënnec during the next century, serves as the

foundation for the whole system of the diagnosis of diseases of the thorax. His method was that of direct percussion, i. e., directly tapping the chest with the finger tips of one hand, as opposed to the present-day practice of "mediate" percussion, whereby the tapping force is imparted to the fixed finger of the other hand, which lies on the chest. The result is a well-known phenomenon of physics. The contents of the air-containing spaces in the healthy lung are set into vibration and give off a resonant note. With practice, the finest variations and gradations in pitch, intensity and quality may be determined, and by virtue of this practice and of our heritage from Morgagni, an accurate system of chest diagnosis has been evolved. It seems remarkable that this illustrious Styrian did not stumble upon auscultation while making his tests as physician-in-chief to the Hospital of the Holy Trinity at Vienna, but in spite of this sin of omission his discovery ranks with the three greatest products of eighteenth century clinical medicine, the other two being those of Morgagni and Jenner.

The first grand achievement of preventive medicine, the ultimate aim of all medical trend, was due to the work of Edward Jenner, during the closing decade of the eighteenth century. This son of a vicar of Berkeley was born in Gloucestershire, on May 17, 1749, received his early education in the local schools, and because medicine had been chosen for him began his professional studies under Mr. Ludlow. In his twenty-first year he proceeded to London, became a favorite pupil of John Hunter, and lived at the latter's house for two years. Here he refused an offer to accompany Sir Joseph Banks's voyageurs on their second cruise, and returned to

his home to practice his art and to be with his elder brother Stephen, of whom he was very fond. Here he lived the quiet, humble life of the country practitioner, marrying, in 1788, Catherine Kingscote, thereby consummating a union of lifelong value to both partners. Not until 1775 did he make his first careful investigation of the subject of this description, but since the time of his apprenticeship under the surgeon of Sodbury (Mr. Ludlow), he states that his interest had been attracted to the relation existing between smallpox and cowpox. It was a matter of fairly wide observation, even during the youth of Jenner, that individuals who had cowpox seldom or never contracted smallpox. A farmer of Dorset, named Jesty, had even performed the act of inoculating his wife and three of their children with cowpox matter in 1774, shortly after Jenner had left John Hunter. But aside from these limited observations and this sporadic accident of a country bumpkin, no serious thought had been put on the subject of the prevention of smallpox by vaccination with the virus of cows suffering from vaccinia (cowpox, "grease" of horses, etc.) The practice of direct inoculation of variola (smallpox) from person to person may have been prehistoric—it is certainly handed down from antiquity. India, China, the Hindus, the Egyptians and the Arabians have successively been blamed for this dangerous practice, whose virtue rested, of course, in the fact that the disease was ordinarily transferred to the victim (usually a child) at a time when he was in the pink of condition, and when he was best able to withstand the dismal effects of the disease. Sydenham was the first to make a serious study of the disease in England, and during the whole of

this century the practice of inoculation was spread throughout both the island and the continent. The famous clergyman Cotton Mather was bitterly attacked and even threatened with death when he suggested its use in the great American epidemic in 1721. But even the royal families of Europe resorted to the danger of direct inoculation, rather than rest in the horrible uncertainty which always attended its epidemic appearance. Jenner himself, at the age of eight, was put under the usual "preparatory régime," and "For six weeks," he tells us later, he "was bled and purged, and kept on a low diet, and dosed with medicine, and was then removed to one of the so-called inoculation stables, and haltered up with others in a terrible state of disease." Fortunately for the world, he escaped with a mild attack.

The steps of Jenner's analysis of the problem are beautiful. First he observed that dairymaids (in which the district abounded) who had been fortunate enough to contract cowpox from the objects of their daily attentions, did not contract smallpox. From this fact alone he must have gotten his first dim idea of immunity, and it was but a logical step to the production of a harmless and artificial protection against the malady. But here was the vital step, and he could not follow the simple expedient of a Hunter and a Harvey, by performing the experiment on an animal. It required, in the first place, a knowledge of the facts and a belief in something of which he lacked the proof. Secondly, he needed a supreme courage, which even Pasteur but falteringly displayed, and third, and most important, he needed a sufficient number of nonimmune human beings with which to prove his proposition.

With a faith, surely no less exalted than Abraham's, in November of 1789 he inoculated his own son Edward, an infant of eighteen months, with material obtained from an animal ill with swine pox, and observed during the following anxious week that the child suffered, to all appearances, a mild attack of smallpox. In 1791 he repeated the dose, and noticed that except for a small "erysipelas" the inoculation had no effect. In 1796 he performed his first conclusive experiment. An epidemic of cowpox broke out in a neighboring farm, and a dairy-maid contracted the disease. On May 14 he inoculated the arm of a healthy boy of eight years with material from a sore on the maid's hand. The boy promptly developed ulcers, which later disappeared, leaving scabs and subsequent scars. Six weeks later came the ultimate proof. On July 1 he inoculated the lad with true smallpox material, and was delighted beyond measure when, after watching his patient for a week, he saw that no smallpox developed. In 1797 he clinched his remarkable proof with three more cases, the delay being necessary because the epidemic of cowpox had disappeared! On submitting the results of his four observations to the Royal Society, they were rejected as being insufficient. By the end of the next year he had twenty-three cases and published them himself in the form of a pamphlet on "An Inquiry into the Causes and Effects of the Variolæ Vaccinæ." In spite of the opposition and jealousy of Ingenhousz, Pearson and Woodville, his discovery rapidly gained recognition, so that by the year 1801, Sacco of Milan had vaccinated over 5,000 Italians. Thomas Jefferson had requested the vaccination of some members of his family, and four years later, Napoleon or-

dered that all his soldiers who had not had the disease be vaccinated. To-day, though the discovery is a hundred years old, it is compulsory in only Holland and Prussia, though most of the military organizations of the world require it, and profit thereby.

The genius of Jenner's work lies not so much in fact of the discovery, but rather in the vision he displayed and in the completeness of his proposition and its experimental proof. Like Harvey and Pasteur, with whose names his certainly ranks, he lived to see his work universally accepted, and to receive the tribute of an appreciative world. The freedom of most of the large cities of the British Isles was tendered him. The House of Commons voted him a present of £20,000. He modestly refused honors from Germany and Russia as "belonging exclusively to men of independent means." Even the Indians of North America sent him a curiously worded note, accompanied by a belt of wampum, in appreciation of the gift which has made one of the most terrible scourges of the human race a preventable disease. His last years were shortened by the grief following the loss of his wife in 1815, and by the scurrilous attacks of a few members of his own profession, together with the great mass of abuse heaped on him by the laity. Such is the price of genius, and on January 26, 1823, he paid the last great debt in succumbing to an attack of apoplexy. The world owes no greater obligation than that to Edward Jenner.

The story of vaccination brings this century to a fitting close, and Morgagni, Auenbrugger and Jenner give us a glimpse of the prodigious activity of the medicine of the nineteenth. Nothing remark-

able "per se" had been done in America, although John Morgan (1735-89), William Shippen (1736-1808) and especially Benjamin Rush (1745-1813) were prominent as Revolutionary War surgeons, and the last named contributed some valuable descriptions of diseases (dengue fever, epidemic yellow fever, and insanity). Our well-beloved Benjamin Franklin (1706-90) invented the bifocal lens, and wrote letters of value on lead poisoning, gout, medical education, and deafness. The Revolution of the colonies found them sadly lacking in "medical preparedness" and afforded American medicine its first great stimulus.

Space will not permit us to delineate further the European achievements of men like Scarpa (1747-1832) the surgeon and anatomist; William Smellie (1697-1763) who first laid down the rules for the use of the obstetric forceps; George Martine (1702-1741) who revived clinical thermometry; William Heberden (1710-1801), whom Samuel Johnson called "ultimus Romanorum, the last of our great physicians," and who wiped out of existence many of the useless "anti-venoms and antidotes" of the time; John Pringle (1707-82) who probably is responsible for the idea of the Red Cross of to-day, and who laid down the principles of military medicine; Van Swieten (1700-72), founder of the "Old Vienna School," who gave mercury internally in syphilis, and others who, famous in their day (and ours) did not greatly divert the broad current of medicine, and whose work in no sense compares with that of the men whom we have considered more at length. One fact of the utmost importance to surgery may be noted in closing. Following the founding of the French Academy of Surgery and its

first session in 1731, Louis XV, through the offices of La Peyronie, a prominent surgeon of Montpellier, directed that surgeons be separated from the class of barbers, "wound-suckers," and wig-makers, (whose practice was made illegal) and that they be required to have a degree in arts before undertaking the study of surgery. A similar event occurred in England in 1745, and was due to the efforts of Mr. Ranby, the King's sergeant-surgeon. Here it became a penal offense for an unlicensed person to practice within a seven-mile radius of London. Thus was the art of surgery reunited with its lawful mate on equal scientific footing after a separation of more than 600 years.

CHAPTER VI

MEDICINE IN THE FIRST HALF OF THE NINETEENTH CENTURY

AT the door of nineteenth-century medicine, one pauses in wonder at its splendor, and at the immensity of its structure. A work of this scope, or one ten times as great, could not detail the discoveries and their stories, the failures and their tragedies, the successful experiments and the useless theories, which have attended the development of the modern period of medicine. Even the Golden Age of Pericles and Hippocrates, with all that it meant to the foundation of the doctrine of medicine, seems colorless compared to the rich glory of the hundred years which boasted of Laënnec and Bretonneau, Addison and Bright, Pasteur and Lister, Darwin and Huxley, Helmholtz and Bernard, Virchow and Koch. And these are but a few of the greatest. Every department of this ever-branching science claims its great men, and has its remarkable annals, and during the nineteenth century, it seems as if every phase of life came under the eager scrutiny of the search which began with the Renaissance. On this account it will be necessary to resort to the plan we used during that great revival, when Paré, Vesalius and Paracelsus held our attention—to name the great contributors and to tell their stories. Fortunately for our purposes, the opening years of the century gave but little idea of the wealth to

come, and this fact affords us a convenient division of years. Since Pasteur in medicine and Lister in surgery mark whole epochs in themselves, and since their work appeared almost coincidently, these men will serve as dividing points of the time when such men as Hahnemann were driveling about their "systems" redolent with early eighteenth century theory, and when Holmes and Semmelweis were sensing the first glimmerings of the meaning of "infection"; from the time when Koch discovered the cause of consumption; when obstetrics had become the safe blessing for which it was intended instead of "a sort of nine month's disease" (to use Garrison's expression concerning an earlier period), and diphtheria did not mean death. These two great geniuses of science were born within five years of each other, and were young, active men when the half-century mark had passed, so that their work and the calendar both afford us the privilege of making the arbitrary division.

True, if taken from the standpoint of subject matter alone, no such arbitrary division exists. The prodigious strides in chemistry and physics at first outstripped the science to which they have been as handmaidens. Subjection to mere authority had been removed during the preceding century, and the French Revolution and the establishment of the independence of the colonies had infused the world with a spirit of freedom which with leisure is the prerequisite of cultural advance. As a consequence the tale of medicine and its progress during this hundred years reads like a romance. From the rather cold facts of auscultation and percussion, through the story of puerperal fever, antisepsis and asepsis, the pronouncement of the cell theory and

that of the conservation of energy, ether and chloroform, the discoveries of physiology and the new wholesomeness in the treatment of the insane, down to the cures of hydrophobia and diphtheria, and the prevention of typhoid and malarial fevers, runs a truly marvelous story with achievement as its theme and humanity as its motif.

After mere mention of the names of Pierre C. A. Louis (1787-1872), who first appreciated the value of medical statistics as a means of diagnosis, and who gave typhoid fever its name, and that of his precursor François Broussais (1772-1838), who was only another of the "systematists," we come to the great name of a great but unfortunate man. René Théophile Hyacinthe Laënnec (1781-1826) was born in Quimper (Brittany), received an early training in medicine under his uncle, finishing his course at Paris in 1804. In 1816 he was appointed physician at the Necker hospital, where he began the series of experiments which resulted in the discovery of the stethoscope, an instrument which, when combined with the methods of Auenbrugger described in the preceding century, was destined to revolutionize the whole study of clinical medicine. Previous to this time, physicians had been in the habit of placing the ear directly over the heart in order to obtain what knowledge they could of the heart sounds. It was while using this method that Laënnec conceived the notion of rolling up a cone of paper and placing the base to the chest and the apex at his own ear, and was delighted to find the sounds of the heart greatly magnified and clearer. It is an interesting and simple experiment to perform, and gives one a good relative idea of the value of Laënnec's discovery. With the ear directly ap-

plied to the chest a muffled, distant series of heart sounds is heard; with the cone, the often described "lub-dup" of systole (contraction) and diastole (relaxation) become clear and precise. This is so for two reasons, first, because the cone serves to "collect" the sound, and also because it serves to exclude other sounds (breathing, intestinal rumblings, etc.) from the field of audition. The use of the cone stimulated this astute Frenchman to further improve the idea, and he devised a permanent wooden cone much like the one used in many parts of France to-day. Various improvements have been made, such as widening the flare of the cone, and shortening its height, dividing the apex dichotomously in order to use both ears, attaching tubes of various lengths to the branched apex, all of which served the original purpose of improving the acoustic properties of the instrument.

But Laënnec was quick to see that not only the heart sounds could be rendered more accessible by means of the stethoscope, but that the sounds produced during inspiration and expiration, friction sounds in the pleural cavity (such as occur in pleurisy when the roughened covering of the lungs rubs against the chest wall) and the spoken and whispered voice sounds assumed tremendous importance in various conditions of disease of the thoracic cavity. To-day it stands, along with the thermometer, as a sort of badge of the profession of medicine, and its uses range from the diagnosis of heart lesions to the determination of the most positive sign of pregnancy—the sound of fetal heart of the unborn child. Next to the compound microscope there is possibly no instrument used by the profession by means of which more can be learned, and of greater

precision. Clinicians of Europe and America were quick to see the value of the stethoscope, especially when combined with the mediate and immediate methods of percussion described but not used some sixty-five years before, and revived by Corvisart (1755-1821) in 1808. The frail Laënnec (he became a victim of the disease which, of all others, he especially delighted to study—tuberculosis) sprang at once into fame. He was given a medical chair at the College de France, following the publication in 1823 of his "Traité de l'auscultation mediate" in which he names the diseases of the chest and proceeds to enumerate their characteristic symptoms, pathology and diagnosis (by means of the new method), thereby reversing the order of his first publication of the same name (which appeared in 1819) in which he names first the signs elicited by percussion and auscultation, and then gives the diseases in which they occur. Only for a few years was he able to occupy the chair at the College. The life of a busy clinician is not conducive to the arrest or cure of tuberculous process, and Laënnec suffered the inevitable penalty of his devotion. He died on August 13, 1826, at forty-five years of age, the most eminent clinician of the early part of the century, leaving a memory and a name that are immortal.

There followed Corvisart, in point of time, but whose translation of Auenbrugger's work rose in importance along with that of his pupil Laënnec; Pierre Bretonneau (1771-1862), who contributed the description and the name (diphtherite) of diphtheria (putrid sore throat, anginous croup, membranous croup, etc.), and Philippe Pinel (1745-1826) to whose salutary reforms with regard to the treatment of the insane we are indebted for much

of the modern optimism concerning the treatment and custodianship of these unfortunate and little-understood individuals. Before the appearance in 1801 of Pinel's classic on this subject and that of Reil (*Rhapsodies on the Psychic Treatment of Insanity*) in 1803, the plight of the insane was indeed horrible. Those who were violently insane were often chained to posts and chairs, confined and frequently severely beaten in iron cells, given the most absurd medicines, and fed on a diet of cheap soup, stale beer, bread and too occasionally a few vegetables. Mustard plasters, applications of Spanish fly (cantharides—one of the strongest of the common skin irritants), venesection, emetics (drugs causing vomiting), purgatives, dousings of cold water and the most brutal drubbings were the order of the day—if the patient did not respond, further treatment of the same type was indicated, and a premium seems to have been put on the invention of new cruelties. With the advent of Pinel much of this was changed. With his own hands, and at the risk of his life, he removed the chains from those placed under his care, led them into brighter, sunnier rooms, called a halt on the practices of beating, bloodletting, and blistering, and placed, so far as he could find, calm, lenient and sympathetic physicians in charge of them. The problem of the care of the insane is a great one, even in our day, when so many forms of mental disease seem to be on the increase, but in the beginning of the nineteenth century it contained an added complication of criminality by attendants which we can hardly believe. Of reforms there were many during this hundred years, but none more humane than that of Philippe Pinel.

In Ireland, due largely to the tremendous impetus given the branch of internal medicine by the work of Laënnec, there soon appeared the names of Robert Graves (1796-1853) and William Stokes (1804-1878). The former was the real leader of the Dublin school, and is remembered chiefly for his systematic methods of teaching, and his reforms in hospital ethics. He was one of the first to time the pulse rate by a watch. The latter made himself famous by the adoption of the discovery of Laënnec, and, with John Corrigan (1802-1880), who devoted almost all of his attention to the circulatory system, established the Irish school on a high standard.

England at about the same time boasted of its Richard Bright (1789-1858); James Parkinson (1755-1824), one of John Hunter's pupils; Thomas Addison (1793-1860) and Sir Thomas Watson (1792-1882). A natural result of the invention of the stethoscope was to attract attention to diseases of the heart and lungs. Practically every physician of this period must needs master this instrument, and as might be expected, practically all that we know of diagnostic methods and diseases of the chest are a heritage from this time. Along wider lines, however, Richard Bright and Thomas Addison may be chosen to represent the best of the period. The former is famous for his investigation into the disease of the kidney which bears his name, as well as for his pathological researches on the pancreas and liver. The latter, a colleague of Bright's at Guy's Hospital in London, described pernicious anemia twenty years before Biermer (to whom the Germans give the credit), and the disease of the small glands lying on the upper pole of each kidney

(adrenals, suprarenals) which to this day bears his name.

In Germany, a remarkable thing occurred. Between 1800 and the Revolution of 1848 (again a coincidence in our scheme of dividing the century into halves) German medicine was in the hands of various schools. The New Vienna School, with Josef Skoda (1805-81), its founder, who is famous for his refinements in the Laënnec method; Carl Rokitansky (1804-78) and Johannes von Oppolzer (1808-71) preached the doctrine of "nihilism in therapeutics." Their slogan is best heard in the words of Skoda himself, when asked as to treatment, "Ach, das ist ja alles eins"! (Oh, that makes no difference!) Of these men, Rokitansky is by far the most considerable figure. He is said to have performed more than 30,000 post-mortem examinations during his life, these furnishing the material for his valuable publications on diseases of the arteries and especially on the defects in the septum of the heart (the wall of muscle which divides the so-called right and left hearts). He was the first great genius of the microscope, and the founder of modern descriptive pathology. There was also the Nature-Philosophy School with a jargon of terms and concepts of which even Pythagoras could scarcely have been proud. Happily it lasted but a short time, but the phoenix which rose from its ashes was of only slightly more attractive plumage. This was the Natural History School, whose founder was Johann Lucas Schönlein (1793-1864), and which upheld the doctrine that the classification of medicine should follow that of botany and zoölogy. The effect of the appearance of these three schools was to divert, and indeed, to paralyze

temporarily, any advance in scientific medicine, begun so ably in France, England, Ireland, and America.

While considering these schools and America it would seem pertinent to discuss the question of puerperal fever, for it was due to the efforts of Semmelweis (1818-65), a pupil of Skoda, and our own "poet-physician," Oliver Wendell Holmes (1809-94), that the contagious nature of this nemesis of the woman approaching confinement was established. Dr. Holmes was born in Cambridge, Mass., in 1809. He graduated at Harvard, tried law, and eventually entered medicine, spending two years in Boston, and two in the medical schools in Europe, chiefly those of Paris. He was for a while professor of anatomy at Dartmouth, but returned to Boston in 1840 to resume his medical practice. In 1843 he published his essay on "The Contagiousness of Puerperal Fever," his only gift of distinction to medical science, though his nonmedical writings have served to establish his reputation as a wit and a man of letters. He died in Boston, October 7, 1894. Though most writers before the time of Holmes (Hull, Baudeloque, Young) had taken the uncompromising attitude that this disease was not contagious, the American brought indisputable proof to show (1) that cases developing in an obstetrician's practice were apt to be limited to his practice; (2) that cases of erysipelas which were handled by the general practitioner were apt to be followed by puerperal fever in the same physician's obstetrical practice; (3) the same phenomenon occurred when the practitioner performed autopsies on beings dead of peritonitis, etc., and (4) that the tremendous incidence of infection in young

mothers in the same ward of the lying-in hospitals of Europe was not a mere coincidence. He did not have any idea of the nature or cause of the contagion, though he dared to state the truth that it was probably carried by the physician himself.

Semmelweis, five years later, in the wards of the Allgemeines Krankenhaus in Vienna, where the mortality from this scourge reaching the peak of nearly ten per cent, caused the women of the city to shrink in terror at the thought of a confinement within its walls, noticed the identity of post-mortem findings between cases of puerperal fever and that of the body of one of Rokitansky's assistants, who had died from the results of a wound in the autopsy room. He at once made his pronouncement of the fact of the contagion, and proceeded to institute the simple expedient of having all persons who had any actual contact with maternity cases, wash their hands in chloride of lime solution before and after their presence in the sick room. In two years the death rate sank from 9.97 to 1.27 per cent! The claims of both of these men were met with a storm of protest and scorn. The Hungarian especially was picked out by Scanzoni and others of his time as the mark for an abusive opposition. Skoda alone defended him, and being by nature too prone to moodiness and too sensitive, he broke down under the strain of the unequal battle, and died insane in 1865. Like Laënnec, we honor him not so much for his discovery, but for the fact that he had the courage to live, work and die for a principle. As Garrison writes, "every child-bearing woman owes something to him."

America now looms solidly among the advancing hosts of medicine, and among its leaders were men

like James Jackson (1778-1844), who first investigated the interesting condition of hemophilia (bleeding sickness); John Mitchell (1793-1858) of Virginia, who resembles Dr. Holmes in his literary interests and fame outside the realm of medicine, and the remarkable figure of Daniel Drake (1785-1852) of New Jersey, who migrated to the (then) frontier of the Mississippi, where he gained the material for his two volumes on "The Diseases of the Interior Valley of North America." This work is particularly valuable in that the solidarity of its Americanism is sustained throughout. He was one of our first great physicians who never left his native land. He is said to have received the first medical diploma granted west of the Allegheny mountains, and spent most of his life wandering from place to place in the broad valley he loved. His life and his work were as full of vicissitudes and virility as those of Lincoln. No less eminent than these were the American anatomists Casper Wistar (1760-1818) of "wisteria vine" fame; William Horner (1793-1853) of Virginia, whose work on the finer structure of the eye and some of the operations thereon are among the first truly American contributions to ophthalmology, and John Godman (1794-1830) of the old town of Annapolis, Maryland, who became an indigent pupil of Daniel Drake, and whose history is the story of a vain struggle against poverty and tuberculosis.

To resume the European theme, there follows, first, a series of eminent anatomists (and among these are included those who began to explore all tissues with the newly refined microscope), second, the physiologists, especially of France and Germany, and third, the great group of internists and

surgeons, which, now dignified to possibly the highest professional level they have ever attained, was composed of some of the best-remembered and best-loved figures of history. And we must mention those of lesser fame, but oftentimes of greater works—the great hosts of laboratory workers, dissectors, microscopists, assistants, recorders—a huge humble army of willing workers whose names will never be known, but without whom modern scientific medicine would be and is impossible. Before the time of Pasteur and Lister, Claude Bernard and Virchow, there was an intensive struggle in the laboratories of science between men eager to accumulate new facts concerning life and its preservation, and the facts themselves, present since the world began, and but hesitatingly willing to be known. The whole human body, with each of its manifold and very different tissues, was literally “passed in review” before the anatomists. Unhampered by theory, disregarding anything which they could not see and feel, long ago freed from Galenic and every form of tyranny, small wonder that almost every month of every year is remembered for some new discovery. Leaders among these men were Bichat (1771-1802) of France, Robert Knox (1791-1862) of Scotland, and Charles Bell (1774-1842) of England. In Germany there appeared the great figure of Johann Müller (1801-1858). He began his work in 1830 as professor of physiology at Bonn, and three years later became professor of physiology and anatomy at Berlin, where he remained until his death. He is remembered for his research into the mechanism of the voice, speech and hearing, and for those into the chemical properties of the blood, lymph and chyle,

but especially for his statement of the doctrine of specific nerve energy—the kind of sensation following irritation of a sensory nerve does not depend on the mode of irritation, but upon the nature of the sense organ—in other words, the optic nerve conveying the sensory stimuli to the brain from its delicate endings on the retina, can convey only those stimuli produced by light and color waves; sound, pain, heat and taste cannot be conveyed along the optic nerve. Such a conclusion may seem trite in this day, but it is of profound importance in the physiology of the central nervous system, and is one of its fundamental facts which was not known (or proven) up to the time of Müller. However, it is not so much for the worth of his experiments and discoveries in the field of physiology and anatomy that he is remembered, but rather for the broad influence he exerted upon a dozen or so of his pupils, whose names stand in the front rank of the medical science of all time. For at his feet, for a time, sat Helmholtz and Ludwig, Schwann and Virchow, Kolliker and Volkman, and Du Bois Reymond, men in whose hands the doctrine of medicine had made its most remarkable achievements. Müller was the founder of medicine (in the scientific sense) of Germany, and even Hippocrates, Galen, Sydenham, John Hunter or Osler have had no greater effect on the trend of its progress. A tall, thoughtful figure, of the rarest personal charm, by virtue of his insight into “physiologic speculation” he earned the title of the “pilot of the whole navy of German medicine.”

But it is to the botanists that we must turn for one of the grand concepts of life, a theory on which is founded the whole subject of modern anatomy,

pathology and physiology—the theory of the cell as the basis of all living matter. Theodor Schwann (1810-82), already mentioned as one of Johannes Müller's pupils, was born in Germany, but after the publication of his masterpiece on the cell theory in 1839, he was offered the chair of anatomy and physiology at Liège, where he continued to contribute work of the best kind. Matthias Schleiden (1804-1881) was more of the true botanist than his contemporary, but had also studied medicine. It was while these men were working on the microscopic sections of plants, and various tissues of the human body, that they observed the small, uniformly distributed nuclei of the cells, differing in form and appearance, but presenting a common feature in the fact of their ubiquity. This fact led the latter to state the so-called cell theory: "There is one universal principle of development for the elementary parts of organisms, however different, and that principle is the formation of the cells." On the basis of this theory, Virchow has founded the doctrine of cellular pathology, the physiologic entity of this minute but infinitely potent starting point of growth has been established, and on these same cells will some day rest the discovery of the cause, and let us hope, cure, of cancer. For this disease is purely and simply a phenomenon of cell growth. So far as is known, cancer is not infectious, and we have no reason to think that it is transferable from person to person, though it is true that certain forms occurring in mice can be transplanted. In spite of an enormous amount of work (possibly no problem of medicine has resisted the efforts of trained minds so long and so completely), not the faintest amount of proven evidence can be brought forward

to show that the cause of this "outlawry" of cells is known. Two things seem important in considering its cause. First, any condition of chronic irritation of a particular part (such as smoking; particles of food passing over and "chafing" an area of the stomach; difficult, repeated confinements, followed by disease of the lining of the uterus, etc.), and second, the theory of Cohnheim concerning "fetal anlage" or embryologic "nests." The latter idea assumes that fetal cells are capable of infinite growth (so long as they are nourished), and that in the embryo, groups or nests of these cells become isolated and arrested in their growth. The stimulus to multiplication is removed, but the cells live. Later, in extra-uterine life, these groups of cells once more receive their stimulus, through some unknown agency, and still retaining their embryonic form and capacity, proceed to grow. This is a fairly well-accepted theory with regard to the so-called "teratoma" and "dermoid cysts," in which curious tumors occur bone, teeth, hair, skin, and all sorts of muscular tissue. There is some doubt, however, as to whether the idea fits the true epithelial type of cancer, which is by all odds the most malignant and the most prevalent type of the neoplastic growths which cause death. Cancer is still a disease of unknown origin and a consensus of conservative opinion holds that radical surgery is its most successful antidote. Upon the generalization of the botanist Schleiden, rests the trend of future exploration of its uncharted seas.

Before Pasteur we have yet to consider American beginnings of scientific medicine, the progress of physiology culminating in the appearance of Du Bois Reymond and Claude Bernard, the achieve-

ments of English surgery, the discovery of ether as a general anesthetic, and Virchow. In our own land, during the first part of the nineteenth century, came to light a remarkable series of experiments by William Beaumont (1785-1853), an officer in the medical corps of the army. While on the island of Mackinac, Beaumont was called upon to treat a Canadian half-breed, Alexis St. Martin, who had been wounded in the abdomen by the premature discharge of his gun. A fistula, or continuously discharging sinus resulted, permitting the contents of the stomach to escape through the opening in the abdomen. The army surgeon, with rare perseverance and ingenuity, carried his patient nearly two thousand miles through the forests of Michigan and Ohio, to Plattsburg, New York, in order to study the experiment which an accident had afforded him. He was the first man to observe the act of digestion "at first sight" as it were, and made many valuable observations on the nature of the gastric juice, its periodic flow, and the movements of the stomach. He published his results in 1825.

The surgery of America, which might be designated as pre-Listerian and pre-anesthetic, was chiefly in the capable hands of Philip Physik (1768-1837), sometime professor of surgery in the University of Pennsylvania, who has been called the "father of American surgery"; Wright Post (1766-1822) of New York, who is remembered for his case of successful treatment of popliteal aneurism (arterial tumor back of the knee), using the method of John Hunter; Valentine Mott (1785-1865), who, like his contemporaries in America and his teacher (Astley Cooper) in Europe, directed attention to the surgery of the blood vessels by ligating practi-

cally every large artery of the body (in treating aneurism) excepting the aorta itself. The literature of gynecology of to-day is filled with the names of Marion Sims (1813-83), who, in the country districts of Alabama, devised the crude implements and methods from which later grew his operation for curing vesico-vaginal fistula (a false opening in the bladder usually caused by tears ensuing in difficult labors, and which had been practically hopeless of cure); Thomas Emmet (1828-1919) of Virginia, and Ephraim McDowell (1771-1830), also of Virginia, who performed the first successful series of ovariectomy (removal of one or both ovaries). He was antedated by at least two isolated cases, but as Semmelweis made complete the ideas of Oliver Wendell Holmes, so McDowell placed on a scientific basis the operation which had been performed once in the sixteenth century (by a swineherd!) and once by Houstoun of Edinburgh in the first year of the eighteenth century. The business of according priority in discovery is, of necessity, dependent upon priority of its announcement, and, as a corollary, its announcement in ethical, scientific, and complete form. Jenner's case of the inoculation of his own son with swine-pox material was in no sense conclusive evidence of the success of his enterprise, but when he could put forth twenty-three cases, all of which bore out his contention, the matter was forever settled. On this account, Ephraim McDowell deserves the credit of priority in performing ovariectomy, one of the most satisfactory and satisfying operations of modern surgery. It is also on this account that we hesitate to approach the discussion of a discovery which ranks second only to that of Lister in the art of surgery of recent times, but

concerning which there still remain the whispered mutterings of what was not so very long ago a storm of dispute; this discovery was the use of ether as a general anesthetic.

Back in the times of the first Hindu surgeons, pain, bleeding and infection had been the greatest deterrents of the knife. With the exception of the introduction of the ligature by Celsus, and its revival by Paré, these factors had remained as the bugbears of surgery. Now, within the compass of twenty-five years, we will see all of them obliterated. Instead of Cheselden's "lithotomy in forty-five seconds," with the patient screaming with pain, and enduring the long convalescence attended with its suppurating wounds, we shall see operative deliberation, general anesthesia, and wounds five inches long in almost any part of the body healed within ten days! But there is hardly a more deplorable squabble in the annals of medicine than that which occurred in connection with the first use of ether as a general anesthetic. It is the most useful of surgical procedures, some life-saving operations would be impossible without it; it is a boon to the woman in confinement, and yet the story of its introduction is tinged with suicides, mendacity, and general doubt as to where the credit really does belong. Certain definite facts are known and we will present them. In 1799 while experimenting with nitrous oxide, Sir Humphry Davy made the observation (on himself) that inhalation of this gas produced sensations which caused "ebullitions of mirth" (whence the term laughing gas) and another feeling of "sensation of becoming lost." In his "Researches Concerning Nitrous Oxide and its Respiration," published one year

later, he ventured to say "it may probably be used with advantage in surgical operations in which no great effusion of blood takes place"! Forty-four years later, Horace Wells (1815-48), a dentist in Connecticut, essayed to use it in pulling teeth. He met with a fair degree of success and told a former associate, William Morton (1819-1868) of Charlestown, Mass., of his experience. A short time later he gave an overdose of nitrous oxide to a patient and is said to have committed suicide on account of the patient's death. Morton, knowing from his medical studies that chloric ether (as distinguished from sulphuric ether) was also an anesthetic agent, filled the cavity of a tooth for a patient after the administration of this substance. In pursuing his interest in the subject he learned from Dr. Charles T. Jackson that sulphuric ether (the variety which is used exclusively to-day) also possessed anesthetic properties. In the same year (1844) he pulled a firmly impacted tooth from a patient under sulphuric ether. Meanwhile, in March, 1842, Crawford W. Long (1815-1878), a physician who had only accidentally discovered the effect of the inhalation of ether, gave some to a patient, and removed a small growth from his neck. There is plenty of proof to show that this was the first surgical operation performed while the patient was under the effect of sulphuric ether. But the fact remains that in this, as in several cases on which he operated within the next two years, he made no report of the procedure, and it is only through the certified statements of friends of the profession in this locality that the matter came later to light. In 1846, William Morton, upon application to a surgeon in the Massachusetts General Hospital, prepared the stage for

the dramatic introduction of his new anesthetic, and here, on October 16, 1846, before a small group, he administered ether to a man, while the surgeon removed the tumor. The statement of the patient on recovering consciousness is a commonplace in medical literature, "Gentlemen, this is no humbug"! One month later, still another figure enters this drama in the form of Henry J. Bigelow, who at that time published the discovery with a description of the cases, in the *Boston Medical and Surgical Journal*. It was taken up eagerly by practically the entire medical world. In England the substitution of chloroform was made, but ether remains to-day the safest general anesthetic. The most unfortunate aspect of the whole subject then appeared in the form of a quarrel between Morton and Jackson over the patent rights to what the former called "letheon," a brawl of the meanest order. As to the giving credit for the introduction of ether in producing anesthesia, the reader may form his own conclusions: Davy vaguely prophesied it, Crawford Long first used it, Horace Wells implanted the seed in the speculations of William Morton, which resulted in the first public demonstration at Boston, Warren performed the first surgical operation at which it was used, Oliver Wendell Holmes first applied the terms "anesthesia" and "anesthetic," and Bigelow first published the facts (though he humbly disclaims credit)—the writer will only venture the opinion that, in spite of all its ugly angles, the discovery is American. Dispute on this score is absent.

In the meantime, physiology was claiming its devotees in Europe and the British Isles, and experiments in this science had received a new form and a

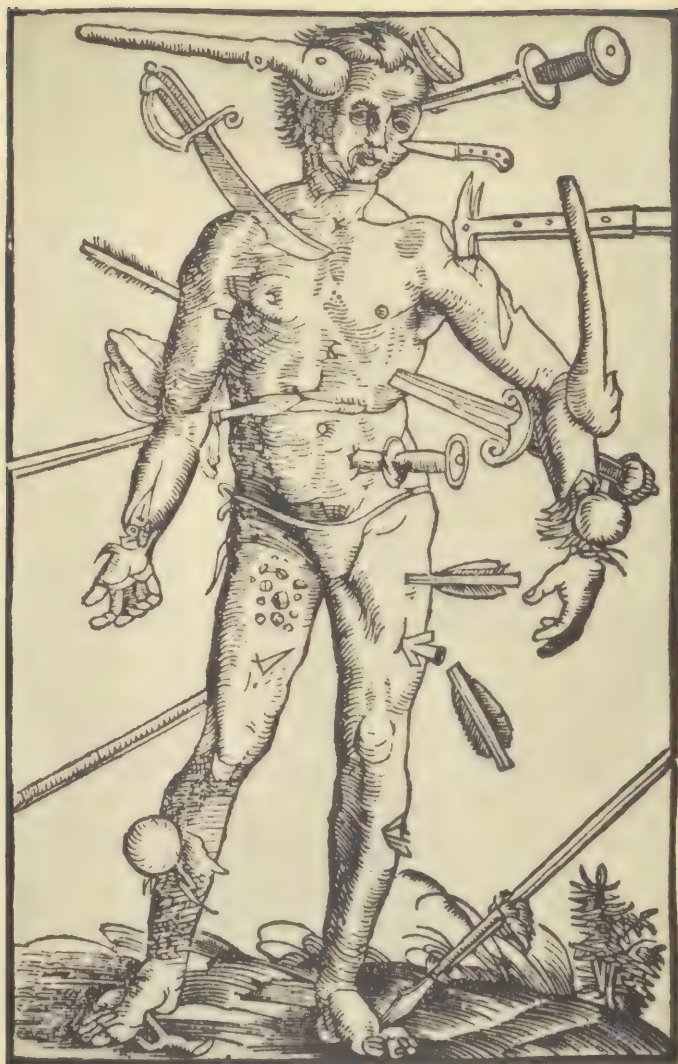
new significance. François Magendie (1783-1885) was possibly the first of his kind in France, and performed many vivisection experiments. Much of his work is disconnected because of his wide variety of interests, but he served to waken interest in such efforts, and the imposing names which follow him pay tribute to his foundation. These are first Flourens (1794-1867), who confined most of his published work to experiments on the brain, and was the first to call attention to the curious anatomical structures termed the "semicircular canals" and to denote something of their physiological significance. By this it is not meant that he discovered them, but he proved that they exist as organs which have to do with the maintenance of equilibrium. It is a well-known experiment in the laboratory to cut one of these minute canals in cross section, usually in the pigeon, and to observe the effects which follow. The bird will manifest rotatory defects in equilibrium in the plane of the canal which has been cut, and in a circle whose axis is at right angles to the plane of the canal. Following Flourens, Jean Leonard Marie Poiseuille (1799-1869) is remembered for his somewhat complicated formula for adducing the viscosity of the blood. These men represent the experimental or physical trend of the period as opposed to chemical. In the latter group are the eminent Justus von Liebig (1803-1873) and Friedrich Wohler (1800-1882), associates and coformulators of many of the fundamentals on which the modern science of physiological chemistry is based.

These beginnings, coupled with the long list of contributions by means of lesser fame, came to a fitting climax in the appearance of Emil du Bois

Reymond (1818-96) and Claude Bernard (1813-78), both of French extraction, and both preeminent in the history of physiology. The former was born in Berlin and was one of that amazing group who had received the instruction of Johannes Müller, and was his great teacher's direct successor in the chair of physiology at Berlin in 1858. His work was almost entirely done on what are called "muscle-nerve" preparations, in which various electrical phenomena are demonstrated on the isolated muscle and its nerve. Almost the entire section dealing with the functions of nerve and striated muscle of every modern textbook on physiology is filled with the "muscle-nerve" discoveries of Du Bois Reymond, and the foundation of the science of electrophysiology has been rightly ascribed to him. Claude Bernard was born in Rhone, France, received his early education at the hands of the Jesuits at Villefranche and gained his first small fame as a playwright! A wise critic in Paris advised him to take up the study of medicine and introduced him to Magendie. The latter was quick to recognize the possibilities of this young pupil, and rapidly carried him through a course of laboratory experiments, and didactic lectures concerning what was then known of physiology. From a standpoint of comparative worth, Claude Bernard was destined to add more to the science of physiology than he ever learned under Magendie, to whose chair of experimental physiology at the Collège de France, Bernard succeeded in 1855. Let it suffice here to say that no man has had a greater influence on the trend of modern experimental investigation in this subject which is, and has been since the time of John Hunter, so closely associated with the progress of medicine

and surgery. The whole subjects of digestion, metabolism and the essentially modern investigation of the physiology of the various "internal secretions," may trace their beginnings to the laboratory at the Collège de France (and later those granted him by Napoleon III) which served as the throne of this prince of physiologists. His funeral was at public expense—an unusual tribute to the work of a scientist.

Three years before the first half of the nineteenth century had passed, there appeared in Berlin the first copy of the "Archiv für pathologische Anatomie" (Archives of Pathologic Anatomy), now known almost universally as Virchow's Archiv. This periodical and its originator are, as Garrison states, "inseparably connected with the rise of modern medical science, German or other." He and Helmholtz were the most brilliant of Johannes Müller's pupils and to Virchow we owe the foundation of "cellular pathology," a science which has made the compound microscope an instrument of precision in the diagnosis of disease second to none. The work which was started by Schleiden and Schwann was brought to a masterly finish and refinement. The dyes for which Germany has become famous were available for staining and preparing sections of every pathologic condition he could find. His private collection numbered more than 23,000 specimens, nearly twice as large as that of John Hunter, and was entirely prepared by his own hands. He was one of the most prolific writers medicine has ever had, and vied with his friend Louis Pasteur in scientific eminence. He epitomizes the spirit of modern medicine in the sense of its democracy and its intolerance toward unproven theory. Like Pirogoff of Russia, he dared to criticize and even rebuke the



"THE WOUND MAN"

Anathomia Mū
dini Emēdata p
doctore melexstat



TITLE PAGE OF "ANATHOMIA," BY MUNDINUS, LEIPZIG, 1493

authorities of Germany (with regard to the famous typhus epidemic in Silesia) and throughout his life maintained a lively regard for the conditions of those unfortunates who stood at the lower end of the Germanic social scale. His medical works are literally too numerous to mention, and since they were chiefly monographic in character, they appeared in his periodical, to which the scientific reader is referred for a series of the best modern writings. But pathology was but one of the "children of his fancy." As an anatomist and anthropologist his fame is but slightly less than that as a pathologist and hygienist. Despite the fact that his political writings in his own journal called "Medical Reform" lost for him the prosectorship at the Charité in Berlin, his subsequent fame as a teacher of pathologic anatomy at Wurtzburg gained its deserved recognition and he was recalled to Berlin and made professor of pathology at the Berlin University in 1856. He had the pugnacious intolerance toward mere speculation that typified John Hunter, but it was tempered by the broad "fraternité" of Ambroise Paré, and by and large, he may be counted one of the most brilliant of Germania's sons.

Of less purely scientific interest were the pre-Listerian surgeons of England, France, Germany and at least one great figure in Russia. English surgery, beginning with John Bell (1763-1820) and Astley Cooper (1768-1841), boasts a splendid series of names. The former of its leaders was famous for his surgery of the vascular system (blood vessels), and the latter, a pupil of John Hunter, was the leading surgeon of his time. He surpassed John Bell and the American surgeons in vascular surgery by ligating the abdominal aorta in 1817. This is an

extremely rare feat even with the refinement of modern methods, and served to add greatly to Cooper's wide reputation. The story of his life is something like that of his great teacher, except for a more complete harvest of its rewards. "No surgeon," states one of his commentators, "before or since, has ever filled so large a space in the public eye." The effect of his prodigious work and his ability as a teacher is seen in the same high type of achievement on the part of his contemporaries and those who followed him. Robert Liston (1794-1847), Benjamin Brodie (1783-1862), and William Fergusson (1808-1877) bear evidence of the high standard of English surgery even before Lister. Surgery in other countries was progressing in no less impressive a fashion. France may point with just pride to its Jean Larrey (1766-1842), a veritable second Paré in his army career and his popularity, Lisfranc (1790-1847), Velpeau (1795-1867), and especially to its Guillaume Dupuytren (1777-1835), who was the ablest French surgeon of the early nineteenth century, and Paul Broca (1824-1880), whose remarkable statistical and actual work on the cranium and brain affords the basis of modern brain surgery. German medicine, while devoting most of its attention to the more scientific aspects of medicine, still numbered in its ranks a few great surgeons. Johann Friedrich Dieffenbach (1792-1847) may be counted as the leader of a smaller and less important group than those of England and France. His contemporaries were Conrad Langenbeck (1776-1851) who is said to have been a more rapid operator than Cheselden; his nephew Bernard von Langenbeck (1810-1887), whose teaching has exercised a profound influence on the present-day surgery of his

country, and Gustav Simon (1824-1876), who was the first surgeon in Europe to remove a human kidney. The father of Russian surgery, and one of the first of the Europeans to adopt the use of ether, was Nikolai Pirogoff (1810-1881), whose name stands foremost among the military surgeons of the world. He was constantly at odds with his military overseers as to the medical management of campaigns, and his belligerence in this respect gained him many enemies among a class to whom the lives of a few Cossacks meant nothing. He was one of the most considerable figures of his day.

It may seem an unfair balance to describe a Pirogoff and to omit a Helmholtz (1821-1894). But the latter's place is deservedly at the top of the list of physicists, and his direct contributions to medicine (except through the medium of his epoch-making work on the physiology of the special senses) are small. Like Bernard, he cannot be fully described in this volume. And on account of space it will be necessary only to mention the names of Max Schultze (1825-1874), the premier histologist of his time; Wilhelm His (1831-1904), who, with Helmholtz, is counted among the most brilliant of Johannes Müller's pupils, and whose work on tissue origin is unequaled; Francis Balfour (1851-1882), the Icarus of English medicine, whose untimely death makes us wonder what "might have been"; our own Henry Pickering Bowditch (1840-1911) and Charles Sherrington, with their beautiful physiological demonstrations; the Russian, Ivan Pavloff (1849-), founder of the modern work on the nervous control of glandular secretion, and a host of others, whose brilliance is dimmed only because their work was not performed in the public eye.

The doors of the laboratory have hidden many a tale of sacrifice and achievement. It is in reality a much more difficult matter to diagnose cancer of the stomach microscopically than by the surgical route, but it is less dramatic, and the modern conversationalist demands a subject of vivid action. The very feet of modern surgery stand on the microscope of Louis Pasteur, but an ironic fate and a complacent humanity prefer to link his name with a process for sterilizing milk!

CHAPTER VII

MEDICINE IN SECOND HALF OF THE NINETEENTH CENTURY

THE MODERN PERIOD

THE second half of the nineteenth century opens with the presentation of the ablest investigators, one of the greatest surgeons, a naturalist without equal, the founder of the science of bacteriology, and the frail figure of a son of France, than whom there is no one more honored in the history of medical activity and achievement. These men are among those who have but in recent times left us, and it is possible that the "perspective of years" will dim the glory now theirs, but to-day their names stand near the top of the lists of medicine, second only to its martyrs. The time has passed when we can easily put our finger on a single man and say that he represents the best of his age. This is so, both because of the multiplicity of "specialties" and details that constitute our modern medicine, and because of the fact that we are now on the very threshold of our own times in which "history" as such ceases. However, in the second half of the nineteenth century, and projected by the continuity of years into our own day, there occur the most interesting and certainly the most vital episodes of medical annals. The whole subject of preventive medicine, which so completely dominates the trend of the medicine of to-day, is a growth of the past fifty, or

even twenty-five years; asepsis has removed forever the last of the "tripod" of the bugbears of surgery; yellow fever and malaria have been conquered; rabies (hydrophobia), diphtheria, and lues (according to Osler) have only lately been classed among the curable diseases, and it is with the stories of these achievements that we must close the historical portion of this work.

Too few are they who nowadays read all the works of Charles Robert Darwin (1809-1882), but it is a matter of common knowledge that his work and his theories concerning evolution are at once the model and the great impelling force behind the growth of modern biology. The queer ideas of Linnæus, the Swedish botanist-physician, had held down even to the time of Erasmus Darwin (1731-1802), grandfather of Charles, who had gained some recognition in his literary pursuits, and had written the "Loves of the Flowers," a poem, in which perpetual identity (as opposed to variation and evolution), if not personification, was invested in each member of the plant kingdom. Charles Darwin was born in Holmes's "goodly company" of Holmes himself, Lord Tennyson, and Abraham Lincoln. He received his early training in his native town of Shrewsbury, and in 1825 went to Edinburgh to study medicine, only to be "disgusted at dissection" and unable to "witness an operation," and after two sessions was sent to Cambridge with a view to preparation for the clergy. His friendships here, coupled with his boyhood bent toward natural history, decided his career, and shortly after graduation he embarked as naturalist on the five-year cruise of H. M. S. *Beagle*—a factor which served to clinch the matter of his choice of lifework and to

furnish the world with "the most wonderful piece of synthesis in the history of science" (Garrison in referring to "The Origin of Species"). It was on this voyage that he gained a practical experience in geology, geography, zoölogy, and natural history, which combined made him an observer second to none. "Perpetual custom," says Cicero, "makes the mind callous and people neither admire nor require a reason for those things which they commonly behold." It is his acute observation of the casual which makes Charles Darwin immortal. Nothing seemed to escape his curiosity and attention, the Andes "sounded with the strokes of his geological hammer," and his specimens littered the deck of the *Beagle* so much as to cause one of the naval authorities to say: "Oh, no, we're not a man-of-war, we're only a — dredger!" But it was the satisfaction of this curiosity and these same specimens which twenty-three years later took the form of "The Origin of Species by Means of Natural Selection," his life's greatest work, and concerning which there has been no other subject of biology more discussed. As has been repeatedly pointed out, the Darwinian theory is neither "completely accurate, nor accurately complete," but the broad principle of evolution, "natural selection as the main, but not the exclusive, means of modification," and the fact of the birth of "every species . . . coincident both in time and space with a pre-existing closely allied species," and the "change of species by descent," are now facts not controverted by those who desire to appear intelligent. Always (since the voyage on the *Beagle*) in poor health, Darwin spent most of his life about twenty miles from London, devoted to further

research and a huge correspondence. His great work created a furore among scientists and he became the point of hot debate. Thomas Henry Huxley (1825-1895), of Ealing, England, and Ernst Haeckel (1834-1919) became the staunch supporters of Darwin and his ideas. The former made a cruise on H. M. S. *Rattlesnake*, similar to Darwin's, and during his later life, by public lectures, teaching and publishing such works as the "Comparative Anatomy of Man and the Higher Apes" (1862), made more specific and permanent the broad theories of Darwin. Haeckel wrote his "Natural History of Creation" in 1874, and may be considered the chief exponent of Darwinism in Germany. Bacon, Goethe, and Herbert Spencer had, before the time of Charles Darwin, known and written of evolution, but the great naturalist and his two disciples placed the idea on a scientific foundation by the formulation of the law in Chapter IV of his work, that "in the struggle for existence the fittest survive by means of natural selection," which he calls "The Keystone of My Arch." Despite its deficiencies, which do not seriously mar the value of his great concept, it has been made the basis of the whole system of zoölogical and botanical sciences and is the means of the nearest approach to freedom of thought the world has ever seen.

But we have more strictly medical things to consider, and it is with delight that we turn to the life and contributions of Louis Pasteur (1822-1895). Born (as his impeachers were wont to iterate) "of peasant origin" at Dole, Jura, he received his early training at Besançon, and a diploma at the Ecole Normale at Paris in 1847. His first scientific interest was that of chemistry, and after what prep-

aration the times could offer him in this subject he devoted particular attention to tartaric acid (the ordinary powder contained in the white paper of the seidlitz combination), and its isomer, racemic acid. An isomer, in chemical parlance, is a compound identical in chemical composition with another, but differing from it in its physical properties. By the use of the polariscope (an instrument based on the principle of the so-called polarity of light when viewed through a crystal of feldspar), he established the difference between "lævo-rotary" and "dextro-rotary" (terms used in connection with the polariscope) tartaric acid. Purely of scientific interest, nevertheless this discovery served to gain considerable recognition for young Pasteur, and in 1848 he read his paper on "Researches on Dimorphism" before the Academy of Sciences. The same year he was made professor of physics at Dijon, and one year later an assistant professor at Strassburg. He became full professor at the latter university in 1854, following further contributions to the chemistry of racemic acid, especially with regard to its crystal formation. In 1853 one whole sitting of the Academy was given over to the youthful chemist, and during the same year, after two failures, he was elected to the reciprocity of the Legion of Honor. It was during this year also that we hear of the first allusion to the subject which was later to modify his whole career and to make his fame spread throughout the world—the process of fermentation. He had discovered that the dextro-rotary tartaric acid fermented and the lævo did not. In 1854 he was made professor of chemistry and dean of the Faculty of Sciences at Lille—a district whose chief commercial interest was that of

the manufacture of wines and beers. We are told the university "grew by leaps and bounds." His rare qualities as a teacher had a chance now for their full expression, and the effect of his presence afforded a stimulus for a large number of young men just entering science. In 1856 a significant event occurred. M. Bigo, a prominent manufacturer of wines, came to him for advice concerning his difficulties in the preparation of beet-root alcohol. As was typical of the thoroughness of Pasteur, he set up a laboratory in the plant of Bigo, and began his experiments on yeast. With his student's microscope, and a few samples furnished by the manufacturer, he began to acquaint himself with the process of fermentation. He observed that so long as the yeast culture remained pure, alcohol of a pure quality was produced, and what was an important additional fact—the fermentation of sugar was attended with the production of glycerine. When the yeast culture changed from its usual bud-like processes and assumed a rodlike form, lactic acid fermentation took place, the wines became sour, and instead of pure alcohol lactic acid was formed in large quantities. These discoveries took him but a short time, worked incalculable benefit to the community, and furnished him with the nucleus for his further researches on yeast. He published the results of his experiments on fermentation in 1857, destroying forever such theories as had been held up to his time as to the nature of the process. Berzelius, the leading chemist of the time, held that fermentation "was due to contact"; Cagniard-Latour actually saw the yeast organism and believed it acted on sugar, "probably through some vegetative effect"; Liebig formulated the doctrine that fermen-

tation was a "chemical decomposition produced by influence." In reading his paper before the Academy, Pasteur did away with such hazy terms as "effect," "influence," and "contact," and substituted for them the idea that fermentation was a process "correlative to life."

But perhaps the greatest result of these experiments and the deductions he made from them revolved about the topic of spontaneous generation. Van Helmont, in the sixteenth century, had given his famous recipe for the creation of mice! Needham and Spallanzani, in the eighteenth century, had "waxed warm" in debate over the spontaneity of generation, the latter by means of flask experiments, much like Pasteur's, taking the stand that life was not "generated from nothing." Pouchet, in 1858, had stated to the world that "animals and plants could be generated." With the true aim of an honest scientific mind, Pasteur plunged directly at the question which had been a source of perplexing speculation for so long a time, and in 1862 published his pamphlet on "Spontaneous Generation." It is one of the best-known works of modern times and its details need not be reproduced here, but when it was presented to the Academy in the same year that he was elected one of its members, he closed his address and his demonstration of the experiments with the prophetic truth: "Never will the doctrine of spontaneous generation recover from the mortal blow of this simple experiment."

The significance of the word "pasteurization" may be better understood by a reference to his advice concerning the diseases of wine. The "souring of wine" had cost the villagers of France untold loss in the sale of their product, until Pasteur

directed that all wine be heated to 55 degrees to 70 degrees C. (a process now applied to milk, certain canned goods, etc.). It was then found, to the delight and financial credit of the wine producers, that the wine was in no way harmed in its taste, and that the product kept indefinitely, or at least "aged" very slowly.

Upon the earnest protestations of Senator Dumas, Pasteur was called to Alais in 1865 to investigate a new disease of the silk industry, called "pebrine," from the fact that the silkworms, in the larval, moth, and adult stages, died in great numbers, "spotted throughout their bodies with black dots resembling pepper." As is usual, the disease had flourished on virgin soil. In twelve years the income from the silk industry had fallen from 130,000,000 francs to 8,000,000 francs, and complete annihilation was threatened. Pasteur was one of France's most patriotic figures and a call from his country was not to be disregarded. Again, with the systematic efforts of a genius, he set about learning the nature of the disease (he had protested to Dumas that he had "never laid his finger on a silkworm"), discovered its mode of infection (the disease is transmitted by the droppings from pre-infected larvæ), and adopted the simple but expensive expedient of destroying all infected larvæ, moths and worms, and importing new animals free from infection, and showed the growers how to keep them free! A second and totally different disease had appeared meanwhile to confuse his experiments, called *flacherie*, and it is to this second scourge that he paid his life's greatest sacrifice. His young daughter had died of typhoid fever, and on October 19, 1868, in the full vigor of 46 years,

he was stricken with cerebral hemorrhage and a resultant paralysis of the whole left side. Few disappointments indeed can compare with those he endured during the next few months, when, in dread of a second and fatal "stroke," he was forced to cease all work. His recovery, however, was remarkable. "With but a slight limp" and some loss in weight, he was soon at work on another of his country's problems, the so-called charbon, or splenic fever of sheep (it is now known by the name of anthrax). In the meantime, however, he had received an honorary degree of M. D. from the University of Bonn, a prize from Austria, and a nomination as senator. He returned the Bonn diploma upon the outbreak of the Franco-Prussian War, and took up again his studies of fermentation, at this time making his famous pronouncement, "Fermentation is life without air."

When he attacked the problem of anthrax, the organism itself had been discovered by Davaine, and Klebs had shown that it was not in the group of so-called filterable viruses (a virus, or disease-producing agency which is small enough to pass through the porous porcelain filter; of such are the viruses of scarlet fever, measles, etc.). Therefore the problem of its cure remained as the point of Pasteur's attack. He hit upon the idea of the attenuation of the virus by drying in successive stages, an idea which he had already formulated in his experiments on chicken cholera, and which later was destined to become the source of his most famous work—the cure of rabies. While working with chicken cholera, he noticed that cultures of the virus which were several days old had lost their virulence and when injected into an uninfected fowl not only

did not cause the disease, but actually protected the bird from an attack following a fresh, virulent culture. He applied this principle to the disease of anthrax, and set the stage for a public demonstration by previously injecting attenuated cultures of the anthrax virus into part of a herd of sheep, and leaving a certain other number untouched. In 1881, near Chartres, he made his great experiment, in the public eye, and with his reputation at stake. He inoculated all the sheep with a fresh, virulent virus. Not one of the previously "vaccinated" sheep died, those unprotected all died. The story electrified the world, and in less than a year Pasteur was given the Grand Cordon of the Legion of Honor.

But in the public mind of to-day, Pasteur is possibly best remembered for his last great work. Hydrophobia had been one of the most dreaded diseases of all time. The mortality was high, but what seemed worse was the tremendous agony of pain in the last stages of the condition. Still following the light of that "most luminous of doctrines," Pasteur conceived the plan of subjecting the spinal cords of dogs suffering with the disease (correctly assuming that the virus of rabies is localized in the central nervous system) to his "attenuating process," in this case consisting of drying for various intervals. Almost before he was ready to announce the success of his experiments upon dogs, a nine-year-old boy, Joseph Meister, of Alsace-Lorraine, was brought to him by the terrorized mother. The boy had been terribly mangled by the bites of a "mad" dog. His high-strung, sensitive nature seemed to have caused Pasteur more anxiety during the period of waiting for the effect of his prophylactic inoculations of

the attenuated virus, than Jenner had experienced in the vaccination of his own son. But the outcome was no whit less brilliant. The lad recovered without symptoms of the dreaded malady, and Louis Pasteur had made the crowning achievement of his life!

Only tribute remains to be written. On September 28, 1895, he suffered from a violent attack of uremia and died, as he had lived, a devoutly religious man and a perfect husband and father. With "one hand on the crucifix and the other holding that of Madame Pasteur," he breathed his last. His remains now rest in a mausoleum in the Pasteur Institute, a noble monument to his life and his work. During the closing years of his life honors were literally showered on him, both by his native land and the world. Few men have lived to see their eminence so acclaimed. "Your health," one of his students had said in 1868, "is not only national, but universal property." Lord Lister, while visiting France after his discovery of antiseptics, publicly avowed that Pasteur had furnished the germ of his ideas. His pupils, Roux and Yersin, Metchnikoff and Calmette, and others have lived to show the effect of the great master. Paul Bert has described in concise terms the contributions he has made to science. "Pasteur has shown that (1) each fermentation is specific; (2) each disease is specific; (3) the microbes of certain diseases become a vaccine (or protection against that disease) under the attenuation of virus."

It is on these facts that the whole subject of bacteriology is based, and on this foundation has the new science of medicine been built. No single man has so quickly and so completely diverted the stream

of medicine, and the grandest work of his life was done after a stroke of hemiplegia at forty-six years! Truly he deserves the tribute which Sir William Osler ascribes to an anonymous pen: "He was the most perfect man who ever entered the kingdom of science."

Next to Robert Koch, the name most often associated with Pasteur is that of Joseph Lister (1827-1912) who, in point of effect on modern surgical science, is the greatest surgeon in history. He was born at Upton, Essex, England, on April 5, 1827, son of Joseph Jackson Lister, a wine merchant, who himself is a famous figure in physical optics through his improvements in the achromatic lenses in the modern compound microscope. The son received his medical education at the University of London, graduating in 1852, and his early surgical training under James Syme of Edinburgh. In 1860 he was offered and accepted the professorship of surgery at Glasgow, and it was here that he was impressed by infection much after the fashion of the immortal Semmelweis at Vienna, and it was here that he later gave to the world the idea of antisepsis. Nine years after his arrival at Glasgow he was made successor to Syme at Edinburgh, and subsequently president of the Royal Society, and a peer of England. He retired from active practice in 1896, after a trip to the Continent, during which all Europe gave him homage. He modestly insisted that Pasteur and Semmelweis had anticipated him, but as Lucas-Championniere said: "Lister put surgery on a scientific basis." He may have been antedated with regard to the idea of infection, but he was the first surgeon to take intelligent steps against the doctrine of "laudable pus," and to hold asepsis as an

ideal. After his death at eighty-five years his body was placed in Westminster Abbey.

At Glasgow, Lister's sensibilities were appalled at the deaths resulting from infected wounds. He describes the "stinking wards," with their huge numbers of suppurating wounds, in a graphic manner, and tells us even before the time of Pasteur's discovery that ordinary cleanliness ought to help the matter. With the advent of the discovery of the cause of infection and pus formation, his work began in earnest. His first dressings were made of various mixtures (zinc chloride, zinc sulphite, etc.) with which he impregnated cloth and gauze to cover the wound. "By chance," we are told, he hit upon dilute carbolic acid, and on August 12, 1865, he used it in the first famous case of compound fracture of the leg. As a refinement he later used "cheese cloth, impregnated with carbolic acid, held in resin . . . (which) on account of its stickiness, required to be diluted with paraffin." He surmised that the ideal mixture was "acid, one part; resin, five parts, and paraffin, seven parts." Here was the first antiseptic (as opposed to aseptic) treatment of an infected wound. In 1867, after repeated use of the method with such additions as "rubber tubing, which had been previously soaked in five per cent carbolic acid, to be used as a means of exit for the pus," and a better grade of soft gauze, he published his results "On the Antiseptic Principle in the Practice of Surgery." In this paper his grasp of Pasteur's idea is masterly and is the premise of his logic. His "carbolic scab," block tin, putty, carbolic spray, "Lister's salts" (double cyanides of mercury and zinc), are now matters of quaint history, but his doctrine of "damnable pus" has come to stay,

and his use of the catgut ligature, "by the antiseptic method," is a fact of modern surgery. He changed his wards at Glasgow from a mere succession of purulent wounds into a place where, "under precisely the same circumstances as before," they had "completely changed their character; so that during the last nine months not a single instance of pyæmia, hospital gangrene, or erysipelas has occurred in them." Despite the clinching power of such proofs, "Listerism" numbered among its opponents some of the foremost figures of the day, but the combination of Pasteur, Lister, and Koch, with their irrefutable experimental deductions, was soon firmly implanted in the dynamic medicine of the time. As to Lister himself, and the epoch he marks, we may fittingly use the words of his great French exponent, Dr. Lucas-Championniere: "After Lister, it was possible to affirm that no one shall die as the consequence of an operation correctly performed."

A brief word may be added as to antiseptic and aseptic methods of surgery. The former, in the sense of Lister's work, is now practically discarded, though in a modified form it has been revived by the work of Carrel and Dakin in their treatment of infected wounds by the use of solutions of neutral sodium hypochlorite, frequently instilled into suppurated areas. But, in a sense, modern aseptic technic (as pointed out by Lucas-Championniere) must be preceded by some antiseptic procedure (boiling, or subjecting to steam under pressure) which renders the instruments, dressings, etc., sterile, or aseptic. Nowadays, in undertaking an abdominal operation, for instance, the whole abdomen is shaved, cleansed with soap and water, and after drying, painted with iodine. The sheets, sur-

geons' gloves, gowns, caps, face masks, are carefully applied by "sterile" hands (i. e., after scrubbing the hands and arms for five minutes, and immersing them in bichloride solution or other suitable antiseptic), and throughout the operation, the operative field and everything which comes into contact with it has been "antiseptitized," or rendered aseptic. The details of procedure vary in the different clinics, but the common end remains—to completely remove any possibility of introducing infectious germs into an area (joint, peritoneal cavity, brain, etc.) which nature has given, and kept, free from infection. If the area has become infected (as in appendicitis, peritonitis, empyema, etc.) the idea still holds. No new infection must be introduced. The cavity is opened under the same precautions, and after the pus is evacuated, drainage is usually afforded by means of rubber tubing or other suitable device. Cleanliness to the point of absolute sterility is the whole doctrine of asepsis.

It is this idea and this method which make possible, and even commonplace, the wide use of surgery to-day. Ephraim McDowell performed the operation of ovariectomy thirteen times in his lifetime, with a record of eight recoveries. Nowadays such figures would consign a surgeon to oblivion, if not to the electric chair. The abdomen is opened almost *ad libitum*, and in cases of doubt as to diagnosis the modern surgeon is amply justified in performing a so-called exploratory laparotomy (i. e., incision into the abdominal cavity for a direct inspection of the offending condition). The insertion of a long needle (carefully sterilized) into the hollow membrane containing the spinal cord and the cerebrospinal fluid is an everyday occurrence in

many of the large clinics. Such a procedure before Lister would have meant almost certain death. Joints are explored, bones are displayed, amputations performed and the wound tightly closed (with the almost certain knowledge that it will remain closed) ; the brain itself comes under the exquisitely careful instrumentation of the specialist. In a good operating room the whole process is made as "fool-proof" as possible, and the entire staff, from the pupil nurse to the surgeon himself, bow to the god Technic.

Thus have we seen pain, hemorrhage and infection disappear as "deterrents of the knife." The writer once saw a patient kept under a light ether anesthesia for four hours (during the removal of a brain tumor), and saw the same patient four months later, alive and well. The ligature, the cat-gut "ties" used by Lister, and the hemostat (a sort of pincers which "catch" on closing) of Halsted have rendered operations on areas literally filled with blood vessels (such as the thyroid gland) an entirely safe procedure so far as loss of blood is concerned. But perhaps the greatest contribution to surgery is asepsis and all it guarantees. Each of us numbers among his circle of friends one or more who has had an operation. If done in recent times in a good hospital, the memory probably consists of no more than an unpleasant fifteen days of lying in bed, and more or less unpleasant ideas about the taste of ether! Let them try to imagine their appendectomies or their herniotomies performed at their home, without this disagreeable ether, and with the whole preparation of the surgeon consisting in turning up his sleeves, and doing that only in respect to his coat! Then let them visualize,

if they will, the four to six weeks of a suppurating wound. Just as "every childbearing woman owes something to Semmelweis," so every person with a cleanly healed wound after an operation owes a debt of gratitude to the name of Joseph Lister.

Pasteur's work was supplemented and beautifully applied by Robert Koch (1843-1910). Born in Klausthal, Hanover, he came under the instructive influence of Jacob Henle at Göttingen. In 1876 he had worked out the cycle of the anthrax bacillus, and described its typical spore form (the anthrax bacillus forms "spores" which are highly resistant to destructive agencies), and three months later he proved that the disease could be reproduced by injecting into an animal cultures which had been grown through several generations outside the body (on nutrient media). We have shown how Pasteur's work so beautifully confirms this discovery. In 1878 he published his masterpiece, in which he describes various organisms which he had obtained in pure culture from surgical wounds, claiming their specificity, and proving it by the same method he had used to prove the identity of the anthrax bacillus. He was promptly raised from the rank of "district health officer" (Kreisphysicus) to that of an officer in the Imperial Health Service (Kaiserliches Gesundheitsamt). He continued in the field of work in which he had so ably started, and by improving the means of culture and staining, he discovered the tubercle bacillus (the cause of tuberculosis) in 1882. Further assignments for this brilliant investigator came swiftly. While at the head of the German Cholera Commission in India, he discovered the cause of cholera (*cholera vibrio*) in 1883. In 1890, he unfortunately announced that he

had discovered a "cure for early cases of phthisis" (tuberculosis). The subject of the rabid controversy which followed this statement was in reality "tuberculin," a killed culture of tubercle bacillus in glycerine broth, which is widely used to-day in the diagnosis only of the disease. In 1898, he was sent to Italy to investigate malarial fever, and in 1906 acted as chief of the Sleeping Sickness Commission to Africa. He was the recipient of the Nobel prize in medicine in 1906. Germany honored him as France had honored Pasteur, and during the past fifty years he has vied with Virchow as the most eminent of the German figures of medicine. He is chiefly remembered now for his discovery of the tubercle bacillus, his perfection of the technic of bacteriology, his methods of typhoid control (1902), and his famous "postulates," concerning the identification of an organism suspected of being the causative agent of a disease. They are:

1. The organism must be present, and obtainable in pure culture in all cases of the disease.
2. The inoculation of pure cultures must reproduce the disease in animals.
3. The organism must be obtainable in pure culture from animals so inoculated and so diseased, and be capable of further propagation.

Koch died on May 27, 1910, of cardiac failure and, following his requested cremation, the ashes were placed in the "Institute for Infectious Diseases," which he had founded in Berlin in 1891. The year of his death brings us strictly into current medicine, and it is altogether fitting that we close this series of the "disciples of Hippocrates" with a brief history of a man who, though of Canadian birth, and who died as the Regius Professor of

Medicine at Oxford, did his best work in an American university, and who perhaps is the nearest prototype which modern medicine can offer of the Healer of Cos.

Sir William Osler (1849-1919) was born in Tecumseh, Ontario, Canada. He was a clergyman's son and came of a vigorous, long-lived race. His collegiate work was taken at Trinity College, Toronto, where he graduated in 1868, and he received the degree of Doctor of Medicine at McGill University in 1872. The following two years were spent in the various clinical centers of Europe. Upon his return he became the professor of the Institute of Medicine at Montreal, in the chairs of physiology and pathology, positions which he filled for ten years. At the end of that time he went to the University of Pennsylvania to become the professor of medicine, and in 1889 he answered the call which brought Welch, Osler, Lafleur and Billings together to open officially the Johns Hopkins Hospital and Medical School. He left Baltimore in 1905 to become the Regius Professor of Medicine at Oxford, a position he filled with all his splendid dignity and culture until his death late in 1919. On the occasion of his seventieth birthday a memorial was held in his honor, to which practically every group of medical men in the world subscribed. A presentation of 700 volumes was made by his brother Regius of Cambridge, Sir Clifford Allbutt.

The growth of the Johns Hopkins Hospital and Medical School under Osler and his colleagues is a matter of American pride. The effect of his European training showed itself in the period of vigorous research which has attended the three decades of the life of the institution. He was our foremost

American exponent of Sydenham's method of teaching scientific medicine at the bedside. His students "lived on the wards," fired by his well-balanced enthusiasm, always sure of a kindly and patient word greeting them at their labors, and looking forward to his "evenings at home"—one of the finest ideas of his fertile brain. On these evenings would be seen the rare qualities of the man as a clinician, a historian, and a man of letters. Many of his students were as familiar with Laënnec as with the device for which he is so famous. Small wonder that he felt just before he died that "through his students" he was in touch with the whole world. In some way he found time to do an enormous amount of original work, among which we may pick as typical his early investigations of the blood platelets, his description of polycythemia (Osler's disease), a condition which is the opposite to anemia so far as the blood picture is concerned, and the description of small, red spots (Osler's spots) which occur in some cases of disease of the lining of the heart (malignant endocarditis). In all, his works comprise 730 titles and extend over a period of forty-nine years (1870-1919). His "Principles and Practice of Medicine" is the best and most widely used medical textbook of its kind in the English language.

"Transplanted" three times, he has done a splendid and honorable work in three countries. We may be proud and thankful that his virile years were spent within our boundaries, but as one of his former pupils said: "Belonging to no cult, or age, or clime, but descended in direct line from Hippocrates, he was Master of the Art of Medicine in its purest form."

CHAPTER VIII

SOME GREAT PLAGUES

1. MALARIAL FEVER

IT is neither rational nor possible to associate the historical development of diseases and the historical development of the doctrine of medicine. Of course they are mutually dependent, but they are the histories of different things. Malaria was known before the time of Hippocrates, but the knowledge of its existence did little to affect the doctrine of the Coan school. Bubonic plague ravaged the earth long before the time of Ambroise Paré, but there is little connection between the man and the disease, and his contribution to medicine, or that of any of his contemporaries or predecessors, did nothing to affect in the slightest the history of the "Black Death." To bring the matter home, the pandemic of influenza of 1918-1919 has baffled the ablest of our investigators. Their history and the history of their effect on the doctrine of medicine would fill volumes, but the history of the present knowledge of the etiology (causation), prevention and treatment of influenza may unfortunately be written in a very few words. On this account, it is our purpose to depict to the reader a few of the interesting methods by which diseases are transmitted, with something of the history of the trials which led up to their ultimate discovery, that they

may serve as examples of the application of the doctrines we have been considering. Most of the achievements to be mentioned in connection with these diseases have been recent. Each of the diseases is old. One of them is the most fatal malady which ever attacked the human race in epidemic form. Another is now practically eliminated. They are picked rather at random from the scores of diseases which have their unique phases, but illustrate beautifully the combined application of every refinement of medicine from Harvey to Koch, and from the eyes of Hippocrates to the microscope of Louis Pasteur.

Few achievements of medicine rank in order of merit with that of the discovery of the identity and the life cycle of the causative agent of malarial fever. The old records of the Hindus and the Greeks before the Golden Age show that the disease existed in those times, and was well recognized and described. Hippocrates even went so far as to distinguish its various forms (tertian, quartan and "quotidian") and to state that it was caused by drinking water from stagnant pools. The first hygienist, Empedocles, during the fifth century B. C. drained the swamps and marshes in the vicinity of the town of Selinus, and records that following this procedure, there was a fall in the incidence of malarial fever. He was deified by the grateful townfolk. Lancisi is usually accredited with making the first suggestion in regard to the possible agency of the mosquito in the inoculation of the disease. In 1618 we hear of the first use of quinine in combating the condition. The Countess Chinchon, wife of the viceroy of Peru, was healed following the administration of cinchona bark, which was

later introduced into Spain in 1640 by Juan del Vigo.*

By the time of Sydenham, Baglivi and Pringle, quinine was widely used in treating the various forms, and an indefinite relation was established between the disease and stagnant pools of water. In 1848, J. C. Nott of Alabama ventured the suggestion that yellow fever and malaria "are probably of insect or animalcular origin." During the latter half of the nineteenth century some of the ablest minds in Europe were engaged in investigating the disease. Edwin Klebs and Tommasi-Crudeli each laid claim to the discovery of the organism, but their mistakes were proven, and it remained for the French army surgeon, Alphonse Laveran, while stationed at Constantine, Algeria, to find the first pigmented body in the blood of patients having malarial fever. One year later, he had improved his technic and described the organism in each of the three forms (now known as tertian, quartan, and æstivo-autumnal) of malaria. Richard of the French army confirmed his observations, and in 1885 Golgi, the histologist, observed that the height of the fever (usually evidenced by a chill, and subsequent fever) was coincident with the phenomena of "sporulation" or segmentation of the parasites. In 1884 Gerhardt showed that the disease could be transmitted from man to man by the simple exchange of blood. So much for the organism. There still remains the question of "How does this microscopic parasite gain access to the blood stream of the human body?" and, what was still more important, "What does the

*These data were taken from the article on Ronald Ross and the prevention of malarial fever, by Wm. C. Gorgas and F. H. Garrison. Sc. Monthly, Aug. 1916.

mosquito have to do with it?" These questions, which are virtually the crux of the subject, were answered in brilliant fashion by Sir Ronald Ross, lieutenant colonel of the British forces in the Indian Medical Service, who set up his laboratory at Secunderabad in 1895, doubting the truth of Laveran's discovery. He straightway set about one of the finest bits of synthesis in medical annals.

First, he proved by experiment that by merely drinking stagnant water, the infection was not necessarily produced. Influenced by the theory of Manson, who had formulated, in concise terms, the concept that the infection in malaria was due to the bite of the mosquito, Ross began by collecting large numbers of all the various types of mosquitoes he could find in the region of Secunderabad. His next problem was to keep them alive, classify them, and later to dissect them and to subject them to microscopic examination. He found the usual three varieties—*stegomyia*, *culex*, and *anopheles*. One by one, during two years, with frequent interruptions attendant upon a rigorous military service, he carefully dissected his minute subjects. Only one of these varieties (*anopheles*) harbors and transmits the malarial parasite, and in a given locality only a small per cent of the total mosquitoes may be infected! However, he had purposely chosen a heavily infected neighborhood, and finally in 1897, nearly two years after his modest beginning, he found one day a few small cells containing pigment in the stomachs of "insects bred from larvæ in captivity, and fed for the first time on a case of malaria." Virchow had described these "pigmented bodies" as being pathognomonic (diagnostic) of malaria. As a matter of fact Virchow had not seen the pigmented

bodies described by Ross, but referred to the deposit of pigment within the liver cells in chronic malaria. The army surgeon correctly assumed, however, that the deposition of pigment is a sort of "badge" of the malarial process, and announced his discovery in written form. "At a stroke," he graphically writes, "they gave both of the unknown quantities—the kind of mosquito implicated and the position and appearance of the parasite within it." He completed the final link in the chain of evidence in 1898 by finding that the spore forms were concentrated within the salivary gland of the mosquito, and not, as he had originally supposed, in the intestinal tract, and one year later Grassi and Bignami proved the important fact that the malarial parasite develops only in the the anophelene species. Concerning the complete cycle of the organism, Ross stated in 1898: "Never in our dreams had we imagined so wonderful a tale as this," and indeed we may search far in nature for a duplicate of the devious route taken by the tiny plasmodium of malarial fever.

Let us take any point in this cycle and trace it. Beginning, for example, with the stage of the chill in the human being, we find upon obtaining and staining a "smear" of the infected blood, that the organism (*P. vivax*, as an example) is not contained within the red blood cell, but floats free in the blood stream in a state of fine segmentation ("segmenter forms"). Within a few hours each of these tiny bodies has fastened itself upon a blood cell, and has grown slightly in size. It begins to consume the hemoglobin of the red blood cell, which grows larger and paler. *P. vivax* is the parasite of tertian malaria, in which the "chills and fever" occur every

other day, so that if we examine the blood a few hours before the chill is due, which many a patient is willing to testify is as "regular as the clock," we will observe that the parasite has grown so as to fill the whole of the red cell, which has but its outer shell left. Just before the chill the parasite begins to form its segmenting bodies, which are eventually disrupted through the covering of the destroyed red cell, and set free in the blood stream. The chill is on, and our human cycle is complete. But where do mosquitoes enter into the thing?

What we have described is called schizogony, and is characterized by the fact that these forms which undergo segmentation and reinfect, are not sexual (asexual) organisms. Their life cycle is limited to the human being, and if sucked in by the mosquito cannot cause further damage. But certain of these forms which fill the red corpuscle do not segment. Instead, they develop into the sexual forms of the parasite (gametocytes) and float free in the blood stream, highly resistant to quinine, and causing no symptoms. They take about twice as long to develop as the segmenter forms and hence are larger and show heavier pigment deposit. There are male and female forms, and their outline, pigment deposit and size serve to distinguish them. But sexual union and fertilization does not occur in the human—who is said to be the intermediate host. It is necessary for the female anopheles (the males are not blood-suckers) to bite and suck blood from a human being, containing the two sexual forms free in the blood, before the mosquito can enter into the cycle. When this occurs fertilization of the female element occurs in the stomach of the mosquito, and almost immediately the fecundated parasite enters the wall of

the stomach. At the end of about seven days, such an infected mosquito would contain numerous small oocysts (sacs) in the muscle of the stomach wall, which are now ready to burst and set free in the body of the insect the small spindle-shaped "sporozooids." Most of these accumulate in the salivary gland of the mosquito, and is the potential equivalent of one of the segmenter forms which occur in the asexual cycle in man. For upon the next "blood meal" which the insect is able to obtain many of these sporozooids are discharged into the blood of the new victim, and we have a new case of human malarial infection. The cycle in the mosquito is termed sporogony, or the sexual cycle. The insect is thus the definitive host of the parasite. To combine the whole history of the plasmodium, we may say (as did Professor Stiles of the U. S. P. H. S.) that there are x asexual cycles in man and one sexual cycle in the female anophelene mosquito. Concerning the identification, life cycle, and habits of the anophelene mosquito the reader is advised to secure one of the excellent pamphlets printed by both the U. S. Public Health Service and the Rockefeller International Health Board on this subject.

2. YELLOW FEVER

According to Matthew Carey, during the months of September and October of 1793 nearly 3,500 people died in Philadelphia, then a city of 40,000, in an epidemic of yellow fever. Nowadays most medical students on graduation from a four-year course in even the largest of our clinics have never seen a case! And the cause of this decrease is the story of a few brave men picked from the United States Army.

The disease is now endemic in Ecuador, that is, there are small centers of population where the disease is constantly present in a mild form but, as Guiteras has shown, capable of rapid extension under favorable circumstances to the ports of America, and thence inland. It is said also to be endemic on the coast of Africa. One of the French armies of occupation in Haiti was almost wiped out by the disease. New Orleans and the entire Mississippi valley was visited by an epidemic in 1878 which caused the death of 13,000. In 1881 Dr. Carlos Finlay had stated he thought the disease was transmitted by the bite of a mosquito. He offered no experimental proof. When the American forces entered Cuba, during the occupation of that island, a group of U. S. Army surgeons consisting of Drs. Carroll, Agramonte, and Lazear, and headed by Dr. Walter Reed, were detailed to study the disease with a view to determining the definite mode of contagion and a means of preventing the spread of the disease.

Frequent mention is made in medical literature of the fact that both the medical profession and the laity had formed the opinion that the disease was transmitted by contact, and more particularly by clothes, bedding, towels, etc. (collectively called fomites). This was the first point of attack for the gallant band of medical officers, and at Camp Lazear, Cuba, in 1900, the first experiments were made. The "postulates of Koch," and, as Garrison put it, "the most rigorous conventions of formal logic," were satisfied in the method and results of each step of the trial. A wooden house was first built in such a way as to shut out all sunlight and fresh air. A temperature of 76 degrees F. was maintained during the 63 days of the experiment, and two enlisted men



AMBROISE PARÉ



WILLIAM HARVEY

and a physician, Dr. R. P. Cooke, volunteered to enter and live in this building, carrying with them fomites from a known case of yellow fever. Every morning the "infected" material was unpacked and handled by these men, and every evening the clothing, pillow slips, sheets, etc., were returned to their boxes by unprotected hands. At the same time, the building was screened so as to prevent the entrance of mosquitoes. None of the men developed yellow fever! Four other "nonimmunes" repeated the experiment during the sixty-three days, in pairs of two, twenty days each. They likewise remained well, and their bravery had furnished the proof that the disease was not spread by means of infected clothing.

The next step was to determine the nature of the virus. Blood was drawn from infected patients and injected into nonimmunes. It was proven in this way that either by injecting the infected blood just beneath the skin or into the vein of the nonimmune, the disease could be reproduced. In two cases the noxious blood was subjected to filtration through a porcelain filter. They showed that subsequent inoculation of such blood produces yellow fever, hence the virus comes under the category of so-called "filterable viruses." Now came the ultimate test. Dr. Carroll was the first to permit himself to be exposed to the bite of mosquitoes which had lived in the vicinity of the yellow fever wards. Within three days he had developed yellow fever. Fourteen cases in all were produced by infected mosquito bites, and by a process of selection and isolation it was determined that the means of transmission of the disease is only through the bite of the female *Stegomyia fasciata*, which, in turn, has received the

infection from a case of yellow fever more than eleven days before. Like malaria, it is Kipling's "female of the species" which "is more deadly than the male." The experiments were at once saddened and glorified by the death of Dr. Jesse W. Lazear of the Commission, whose death occurred as the result of an accidental mosquito bite and the development of yellow fever during the course of the experiments.

From the standpoint of economics, America can boast of no more splendid medical achievement. The disease has been exterminated from the United States. General (then Major) William C. Gorgas, following the proof of the Yellow Fever Commission, instituted rigorous antimosquito measures in Havana and rid the island of Cuba of its most costly disease. He repeated and amplified his work in the Isthmus of Panama during the construction of the canal, and rendered that district free from the diseases which had made the French give up their project years before. As a result of the cooperation of Goethals and Gorgas there is hardly a spot on earth where there is less infectious disease than that same Canal Zone. A group of vigilant, trained men stand at the ports of the country, under the authority of the U. S. Public Health Service, and guard against the entrance of suspected cases. The reader will in all probability never see a case for, because of the bravery and skill of Walter Reed, James Carroll, Aristide Agramonte, and the martyrdom of Jesse Lazear, "yellow fever is no more."

A brief word as to the causative agent. In the 1916 edition of Osler's "Principles and Practice of Medicine" is written (p. 358) "The specific germ

has not yet been discovered." In the 1920 annual report of the International Health Board of the Rockefeller Foundation appears this statement: " It has now become reasonably certain that the organism which Noguchi named *Leptospira icteroides* is the true etiological agent" (of yellow fever). In the same publication it is stated that the disease is still endemic in Mexico and Brazil.

3. BUBONIC PLAGUE

In 1348 over sixty millions of human beings (approximately one-fourth of the population of the earth at that time) died from the pandemic of the "Black Death." During the recurrence of the same disease in Europe during the seventeenth century an added million lives were the toll paid to the "Grim Reaper," exacted by a disease which is spread only by means of the bite of the rat flea. The great visitation of the fourteenth century was probably the most demoralizing cataclysm in the history of the human race. Historians afford us ample evidence for such a statement. Sweeping solidly and inexorably over Europe, claiming vagabond and courtier, scullery maid and princess, "priest and penitent," northward and westward moved its engulfing wave. In its wake were misery, sin and death. Humanity became for the time like the fauna of our western prairies before the consuming flames of the prairie fire. The dominant thought in each mind was to escape the disease. Friendship, family ties, marriage, parenthood, in short every bond of the social and moral systems was cast to the winds. Furiously spurred horses carried the more fortunate of the nobility out of the country, ships carried their heavy loads of people

out to sea, caves and forests sheltered their groups of terrified refugees—anything to get away from “the Pest.” The most repulsive stories of history center about the looting and ravaging in the plague-stricken cities; the race resembled the rodents who disseminated the disease; “like rats deserting the sinking ship,” they scurried each for himself in any direction and using any means which offered the slightest chance of safety.

Beyond a few haphazard “quarantine” measures instituted by Italian rulers from time to time and later by Orräus of Russia in the eighteenth century, which served to check the disease before it had quite spent itself, nothing was done in the scientific study of the disease until 1894, when Kitasato and Yersin discovered the cause of the malady. They isolated an organism from the blood, sputum and various organs of the body which obeyed Koch’s postulates, and did much to stamp out the spread of the disease by suggesting means of prevention, as burning the fomites of the infected cases, more energetic warring on rats, etc. From this time (1894-1896) on the disease appeared in various parts of the world. India between 1896 and 1911 lost five and a half millions, within three provinces. The disease appeared in San Francisco in 1907, and a few early cases were recognized by the splendidly trained officers of the U. S. Public Health Service (then the Marine Hospital Service). The United States Government stepped in, on the earnest pleading of the health officers, and handled the situation with a well-remembered efficiency.

For some time it had been known that during the height of the epidemics, “even the rats died,” but no causal or implicative relation had been proven,

or by many even suspected. It is now known that in those areas where the plague is endemic (India, China), the disease is kept alive by means of its occurrence in rats, ready when the opportunity presents to spread over the world with a fulminating virulence. This phenomenon is thought to occur by virtue of the assumption of a chronic form by the disease in rats. What we know about bubonic plague so far as the cause and mode of infection are concerned, is learned from the studies of the British Plague Commission of 1908. This body left for India in 1905, and reported their results in 1908 (Jour. Hygiene, Vol. VI.). Their experiments are ideals of their kind. Wild Bombay rats were largely used and careful controls, records and autopsies were obtained. Every sort of check was put on each step, to insure accuracy of method. They began with a few known facts. Yersin had shown that the injection of organisms obtained from the chronically infected rats are virulent, and what was most important, he had arrived at the proven conclusion that plague is communicable from rat to rat "either through the atmosphere, contact, or by ectozoa," by the simple demonstration that when healthy and infected rats were put in the same cage, the plague-infected rats died first, but the entire number eventually succumbed.

The Plague Commission cleared up all remaining doubts as to the implication of the rat (*Mus decumanus*) and added the new fact that the transmission of the plague is entirely dependent upon the rat flea (*Pulex cheopis* or *Xenopsylla cheopis*), which serves not only as a carrier by transferring the plague bacillus on its proboscis, but also as a

multiplier of the organism which rapidly increases in the stomach of the flea. The work of the Commission may be summed up as follows:

1. All fleas were excluded. In a mixture of healthy and infected rats, the disease was not transmitted to the healthy. This obtained even in the suckling young of a diseased mother.

2. Fleas were introduced. In a mixture of healthy and infected rats, the disease was rapidly disseminated from rat to rat.

3. Fleas were excluded. One flea was permitted to bite an infected rat and was immediately transferred to the cage of a healthy rat. The latter developed plague.

4. A rat, dead of plague, was laid on the floor. Two cages containing healthy rats were suspended in the air, not in "flea range" of the dead animal. Another healthy animal was placed on the floor "within flea range" and still another was placed within flea range, but surrounded with a barrier to fleas (tanglefoot fly paper). The animals suspended in the air remained healthy. The rat surrounded by the tanglefoot remained healthy. The unprotected rat on the floor developed plague. All rats except the dead animal were caged.

5. Different periods were allowed to elapse between the last feeding of the flea and the first bite of a healthy animal. Forty-five days was established as the maximum time during which a flea retains its capacity for infection, while unfed.

The conclusions arrived at by the Commission may be summarized as follows:

1. Bubonic plague is conveyed from rat to rat and from man to man solely by means of the bite of the rat flea.

2. Certain unexplained cases (laboratory infections, etc.) seem to demonstrate that a few cases (less than three per cent) may be infected without the intermediary action of the flea.

3. The presence of bubonic plague in man is dependent upon the existence of the disease in rats. This applies to epidemics.

4. Fleas may infest clothing, and remain infectious for a long time (45 days), hence the plague bacillus may be and is carried on clothes, bedding, etc. (fomites).

5. Insanitary conditions have nothing to do with the origin or spread of bubonic plague, except as they favor the presence and propagation of rats.

This constitutes virtually all our knowledge of the disease. The bionomics of the bacillus have been studied, but with indifferent success. It has been shown that when the flea has bitten an infected rat, a blood clot rapidly forms in its upper intestinal tract and that the organisms multiply in great numbers in this clot, but its significance is not completely understood. The outstanding feature of all the work done on bubonic plague is, that the secret of its prevention lies in keeping it out of the ports of the country, and in instituting "rat murder" on as large a scale as possible.

4. TRYPANOSOMIASIS

(African Sleeping Sickness)

Sleeping sickness, or human trypanosomiasis is, so far as is known, confined within African limits. Europeans and indeed any race may be attacked, but, like all diseases conveyed by an intermediary, the conveyer itself limits the area of infectivity. Of

trypanosomiasis itself, there are many well recognized forms, some of which have been known for more than a hundred years. In 1879 a flagellated organism (having a tail) was found in the blood of rats. Evans, in 1880, found trypanosome in the blood of horses and cattle having the disease known as surra, and observed that camels and elephants also harbored the minute parasite. Bruce convicted this organism of guilt in causing the tsetse fly disease, or nagana, in 1895. In 1890 Nepveu had described a trypanosome found in man, while on malaria experimentation in Algiers, but the description is incomplete and mentions no causal relation with any disease. Dutton found, in collaboration with Forde, in 1901-2 the first reliable evidence of human trypanosomiasis, in the blood of one of the natives of the Gambia river colony, and in 1903 Castellani, upon finding small flagellate bodies in the blood of several cases of "African sleeping sickness," suggested them as the cause for the disease. Bruce and Nabarro, members of the Royal Society Commission, proved this assumption and showed that it was transmitted by the tsetse fly (*Glossina palpalis*). The final step in establishing the mode of infection was made by Kleine in 1909 when he showed that the tsetse fly was not like the flea in bubonic plague, but was a true intermediary host of the trypanosome. Others have shown that in practically every form of the disease, there is one fly or another which acts as a true intermediary host, much as the anophelene mosquito does in malarial transmission.

While of but passing interest to the inhabitant of the northern latitudes, nevertheless the incrimina-

tion of the tsetse fly as the transmitting agent of the fatal "sleeping sickness" of the West African natives, was, as Osler remarks "the most important recent find in tropical medicine." Thousands of these aborigines had died each year, anemic, irregularly feverish, wasting, gradually being overcome with the lassitude and lethargy which is so characteristic of the disease. Quaint indeed are the stories of this disease and what the Africans have held to be its cause. We see superstition, horror of the supernatural and fear of "spirit punishment" in their most primitive form.

Now, while it is by no means entirely curable, it is known that antimony compounds serve to allay its course, and Ehrlich's "atoxyl" has been proven to be of marked benefit in its treatment. There are records of nine cases of cures among Europeans (Osler).

Koch holds that the crocodile is the chief source of the infection. The disease is certainly more prevalent along the rivers (Gambia, Uganda, etc.) than on high dry land. The German bacteriologist holds that the tsetse fly feeds on the crocodiles along the banks of the river and after the intermediary incubation is past transmits the disease to humans. The fly is thought to receive the infection in the stomach and upper intestinal tract. A sexual cycle is thought to ensue after which the young (unflagellated) organism finds its way into the blood stream of the fly. Many of these are eventually collected in the salivary gland, and after thirty-two days the fly is said to become infectious, a phenomenon which continues for about twenty-five days. There is no doubt whatever that the near future will display further discoveries concerning this most peculiar

of diseases. It is spreading because Africa is being opened up, and it will become a matter of necessity to do further work toward its prevention. A prophecy is not out of place. As with the mosquito in malaria it seems rational to assume that the logical point of attack will be the eradication of the breeding of the tsetse fly.

CHAPTER IX

MODERN MEDICINE ACHIEVEMENT

ADVANCE OF PREVENTIVE MEDICINE ROCKEFELLER FOUNDATION

THE most fruitful trend of modern medicine seems to be that of aggressive prevention. This is almost entirely a twentieth-century growth, and promises the only apparent success against diseases like tuberculosis, malaria, hookworm, yellow fever, bubonic plague, typhoid fever, all of which are, in a sense, preventable. The cause, life cycle of the offending organism, method of transmission and the intermediary and definitive hosts of each of these diseases are known. Their pathology is completely worked out, and the point of attack toward their eradication has been carefully considered in each case. There remains only the aggressive waging of the war against mosquitoes and rats, the education of the masses with regard to their hygiene, and the use of such proven vaccines as will afford an almost positive protection against diseases like smallpox and typhoid fever. This struggle and this education have been going on for a while beneath our eyes, but only within the past year or two has the war for public health gained great impetus and the attention it deserves under the leadership of the International Health Board of the Rockefeller Foundation.

This immense fund, reaching at present into the hundred millions, is furnishing an income which is being devoted in two chief directions, the promotion of medical education throughout the world, and the furthering of the idea of preventive medicine. In one instance the ideas are combined. The entire expenses for the year of 1919 of the School of Hygiene and Public Health at the Johns Hopkins Medical School, were paid from the Rockefeller Fund. The latest available reports (those of 1919) show that the assistance to medical education was given largely in the country of China. The Peking Union Medical College opened its doors in 1919 by virtue of aid from the Foundation, premedical courses were assisted in Changsha, Nanking and Shanghai, medical courses in Tsinanfu, and more than fifteen hospitals were made recipients of aid from the fund. Aside from the Hopkins School of Hygiene, aid was given toward the maintenance of a similar school at the Sao Paulo University of Brazil, and seventy-two international fellowships in public health were granted to students from Salvador, China, Brazil, Czecho-Slovakia and the United States.

But by far the most brilliant and the most immediately fruitful results were obtained in the actual application of known principles of public health and preventive medicine. During last year these efforts were directed against yellow fever, malaria, hookworm and tuberculosis. We have hinted at the achievement made by the Rockefeller Foundation concerning yellow fever in the chapter on that disease. In 1918, under the leadership of General Gorgas, the Yellow Fever Commission embarked for Guayaquil, Ecuador, Dr. A. I. Kendall

of Northwestern University in charge, with Hideyo Noguchi as chief bacteriologist and serologist. Guayaquil had been one of the endemic foci of the disease, and several cases were placed at the disposal of the commission. The local profession furnished valuable aid in every branch of the work, and the combined efforts of the Ecuador physicians and the Commission resulted in the following hopeful facts:

1. Noguchi, in experiments on guinea pigs, dogs and monkeys, was able to transmit the disease by blood inoculation, and succeeded in isolating a spiral organism, which "in all probability is the cause of yellow fever," and which he named "*Leptospira icteroides*," the "slim spiral, the jaundice maker." He was also able to prepare a protective serum.

2. In 1918 Guayaquil reported 460 cases of yellow fever. Almost entirely due to the efforts of the local authorities, antimosquito measures were instituted in November 1918, during which month 81 cases had been reported. Despite vigorous measures, 88 cases were reported in December, and 85 in January 1919. In the face of public disappointment the American director "made a plea for suspension of judgment" and all efforts were redoubled. February showed 43 cases, March only 17. April and May saw the full effect of the work of the campaign and only 3 and 2 cases were respectively reported. Since June, 1919, there has been no case of yellow fever reported in Guayaquil! This freedom had not occurred since 1842.

A similar activity has been in progress in connection with malaria. The point of attack is the same. Rigid antimosquito measures were instituted in Mississippi and Arkansas, chiefly as a demonstration

that this disease is entirely within means of prevention. Further tests were being made early in 1920, but the results obtained after the work had been in progress only nine months were nothing short of brilliant. A sample may be quoted. In the town of McGehee, Arkansas, in September, 1918, 246 cases of malaria put in calls for physicians. In the same month one year later, only six such calls were made! Antimalarial work started in April, 1919.

By far the work of widest scope attempted by the International Health Board is that of hookworm control. This is one of the most widespread of diseases, and in parts of China, Porto Rico and Dutch Guiana, the infection of 90 per cent of the population is an established fact. It is an intestinal infection which, by causing anemia, retardation of growth and their attendant impairment of physical and mental function, puts it among the front rank of the serious diseases with a low mortality. During the year of 1919, eight new districts were entered by the antihookworm measures, twenty-five maintained the work already begun, and in two was the effort discontinued. In this direction, the aim of the Board is essentially this: A few separate districts are chosen and preventive measures are inaugurated against the disease, under a carefully chosen leadership and using as far as possible the local talent. The experiments are uniformly successful in bringing down the incidence of the disease. The public is quick to appreciate the significance of preventive measures, and the Board relies on this fact in the furtherance of the campaign, the idea being to "step out from under" eventually, and to let the work go on under the leadership and expense of the

local and government authorities. The whole secret of the prevention of hookworm disease is sanitation and the proper disposal of the excrements. The human being and the soil are the only known hosts of the hookworm. The disease is "easily curable," but, in the presence of polluted soil, reinfection is not only just as easy, it is practically certain. Hookworm is now classed among the entirely preventable diseases, and it seems not at all Utopian to assume that, due to the efforts of the local Southern authorities, the United States Public Health Service and the Rockefeller Board of Health, the disease will eventually disappear as yellow fever has, from the borders of our country.

"No quarter" has been declared in our war with France. It is not generally known that we are engaged in mortal combat on the soil of our great ally. "With France" is written advisedly, for the International Board of Health is combining with the French Government in a vigorous campaign against tuberculosis, which during the war was almost a universal scourge in this sorely-pressed country. It is not that we are attempting to "educate" the people of France concerning tuberculosis—French physicians could probably show us more knowledge than we ourselves possess—but rather that the Rockefeller Foundation sees the opportunity and offers its aid, and that the Board of Health lives up to its name in being truly international. George E. Vincent, President of the Foundation, has described in a recent report (1920) the objects of the work in France, as follows:

1. The setting up in typical urban and provincial areas of standard demonstrations of systematic control methods.

2. The training of public health nurses, clinicians, lecturers, and organizers.

3. The arousing of communities to the need of creating local agencies, governmental and voluntary.

4. The educating of the public in the causes, treatment, and prevention of tuberculosis.

5. The gradual transfer of responsibility to French agencies and organization of these agencies on a national basis. (The crux of the campaign.)

Such work, in many lands, is the grandest thing of its kind ever attempted. No expense is spared, once the aim is taken. The best hygienists available are obtained, field staffs are maintained throughout the world, and on the Board itself serve some of the ablest men of our day. Up to our time it is the best application of the idea of preventive medicine, which in turn is the most humanitarian doctrine in the history of science.

SUMMARY OF ACHIEVEMENTS IN PREVENTIVE AND CURATIVE MEDICINE IN THE WORLD WAR

Italy alone of the nations of the world entered the war with an adequately prepared medical department, although Germany was far ahead of our allies in this respect. Almost over night, we were confronted with the necessity of increasing our medical corps to forty times its strength and with equipping and training it for war purposes. Furthermore, this had to go on while all the available physicians were serving on draft boards, teaching in the various medical centers, and taking care of their practices, made doubly great by the influenza pandemic of 1918. The story of the American physician's response to the call is only that which he always makes: "I'll be there as soon as I

can." His record, after he came, is unimpeachable. Thrown into a new environment, he rose admirably to the occasion and in almost every instance forwarded nobly the cause of a corps, which soon became second to none. It will be of benefit to trace something of the record of his achievement, and in so doing to describe the progress of medicine which always attends the march of armed forces and the building of their bivouacs.

1. The establishment of the medical corps of the United States Army.

The United States declared war on Germany on April 6, 1917. Twenty-four hours later, the complete plans for the establishment of a number of Medical Officers' training camps to be located at various points in the United States, were laid on the desk of the Surgeon General.* These were ultimately concentrated at Fort Oglethorpe, Georgia, with the medical section at Camp Greenleaf. On this same April 6, the officers in medical corps in the regular establishment numbered about 500. About one year later, there were approximately 20,000 physicians called from the civil population to don khaki, to familiarize themselves with the caduceus and the various insignia which at that time were adorning the shoulders of "our Docs," and to learn the business of becoming army surgeons. To the shrine at Fort Oglethorpe came the best young surgeons of our day, and came also that most honored of national figures—"the country doctor."

Of the stories that are interwoven with the bustle of departure, the separation from home and patients,

* Our New Army Medical Department. F. H. Garrison, N. Y., 1918.

the change from giving to taking orders, many are humorous, a few are tinged with sadness and death, but all are fearless. The establishment of the U. S. Army Medical Corps will go down in history as one of America's proudest and most unselfish achievements.

As to the training at Oglethorpe, we would say as do the advertisements, "Ask your local dealer." The adaptability of the American physician was seen at its best. Shorn of the glamour of his local standing, he was not even permitted to wear the insignia of his rank until his "course of sprouts" had rendered him fit. If your physician was fortunate enough to have been to a medical officer's training camp, you have seen him come back a better man. He learned that next to the Quartermaster's Corps, which governs the maintenance of supplies, he was a member of the organization on which the success of his army chiefly depended. He learned the "paper work," the drill, the manual of arms, guard mount; if he was a specialist, his training was utilized, if deficient, he was taught, and he saw a few, who for their sheer stupidity and negligence, were court-martialed.

But perhaps what impressed him most was the organization to which he belonged. He may never have seen the Surgeon General, but he knew there was such an officer, sagacious and patient, directing his Corps which, before the Armistice was signed, was greater than the whole army had been on April 5, 1917, and who was directly responsible for the health of three million men. In due time, the figures and facts of this enormous achievement will be made public by the Surgeon General's Office.

2. Inspection and sanitation of cantonments.

It is not our purpose to give in any detail the various procedures of training, equipping, and assignment to duty of the officers of the Medical Corps, but rather to present a few facts concerning what was done by American physicians when they so generously responded to the call of war. The Medical Corps was, so far as its officers were concerned, almost an entirely volunteer corps. Almost any physician could have been exempted from the draft had he so elected, but evidence of an almost universal choice to serve is shown in the very existence of a corps of fifteen to twenty thousand men.

And to many of these men, the whole idea of army life was new. The newest thing of all was probably the idea of preventive medicine so completely and aggressively applied in the huge cantonments. For your physician cannot enter your home or that of your neighbor and direct you to screen your kitchen; he is not in the habit of telling all the young men and women in the locality that they must report to his office for typhoid vaccination at such and such a time; and when he observes (and he does) that you and a few of your neighbors are working too much or too little, that your fat is accumulating or diminishing too rapidly, he cannot order you to report at seven a. m. on the town square or the college campus, clad as the occasion demands, for an hour's "setting-up" exercises. He is bound by an iron code of "ethics" to wait until the flies in your kitchen have transmitted the typhoid for which he could not order your vaccination, or until your embonpoint or your osteologic prominence begin to attract the attention of friends and in desperation

you have sought his advice. Not so in the army. He not only can do the things which his training and his judgment tell him will keep the soldier at the highest point of physical efficiency—he must. With regard to the sanitation of camps he was placed in a unique position.

Before and during the Civil War, the medical officer was tolerated by the line officers. He could execute orders only with regard to his own command—a second lieutenant in the Quartermaster's Corps had virtually more authority over the movement and disposition of troops than the medical major. In the World War, such evils were in a large measure corrected. True, the authority, as such, of the medical officer is limited to his subordinates within his own corps, but his recommendations are given an attentive ear by the Commanding Officer, and his responsibility and authority in all matters pertaining to the health and welfare of the men to whom he is assigned are, to all intents and purposes, absolute. It became therefore his duty to inspect camps, to report on conditions existing in the vicinity of the cantonments, such as drainage, water supply, food supply, marshes, etc., and to assume direct intimate charge over the physical condition of the troops. The great epidemics of influenza, measles and meningitis taxed his ability to the utmost, but as has been repeatedly and wisely observed, the mortality from the diseases which occurred in our cantonments was not higher than that which characterizes the same diseases in the civil population of the same age and sex. Other new and difficult problems were the venereal prophylaxis, rarely a short-sighted and long-winded commanding officer, and the worst of all—the

malingerer. But in spite of these, he kept the large concentration centers for the raw recruits clean and wholesome, saw that soldiers obtained well-balanced and cleanly cooked food, was ready to examine them at any time from head to foot, and to help their ailments, roamed the camp on his inspection trips day and night, answered any and every call, doing his very utmost to keep his men "fit to fight." You and your community may have the advantage of the best system of sanitation in the world, if your physician was trained at Riley, Oglethorpe, or other training centers, and if you ask him to apply that training to your locality.

3. Carrel-Dakin treatment of infected wounds.

Dakin and Carrel, on the French front, experimented with more than two hundred antiseptic methods for use in infected wounds, selecting finally a neutral solution of sodium hypochlorite. In the presence of the body fluids, such as the blood and serum which always cover the surface of a wound after a few minutes, sodium hypochlorite solution gives off active chlorine, which unites with an organic substance present in the fluids, and forms the so-called chloramin. The latter substance is a powerful germicide. Dufrausne has improved the original method advocated by Carrel and Dakin by making a solution of the same substance, but omitting the addition of boric acid. Dufrausne's solution has the advantage of being more stable, and capable of preservation for weeks if kept in a cool, dark place. The original Carrel-Dakin solution had to be prepared fresh each day. Aside from the omission of boric acid, the solutions and their action are identical, and aim at the common purpose of removing all traces of caustic alkali from the

completed product. The solution must be made with great accuracy. If below forty-five one-hundredths per cent, its action is rendered insufficient to control infection, if above one half per cent, too much damage is done to the skin around the wound, and the resulting burn may become worse than the wound itself.

The technic of administration is not simple. All skin edges should be protected with vaseline or zinc-oxide ointment. The small sterile rubber tubes, open at both ends, are then inserted into all the "pockets" of the wound, and (usually) tamped with soft, lint-free gauze, to insure their security. One end of each tube is permitted to protrude through the whole dressing and is kept closed by means of a suitable clip. An abundance of soft gauze is then placed over and about the wound. The solution is then instilled into each pocket of the wound at intervals of two hours during the day, and four hours at night, until the "bacteria curve" shows the wound to be free from infection. The wound is then sewed tight, or allowed to heal by granulation, according to the judgment of the surgeon. The use of the solution has not been universally applied, probably because of its difficulty of administration (necessitating a large hospital force, careful chemistry, and large amounts of material), the danger to the surrounding skin edges, and the extreme accuracy needed in its preparation.

A French mathematician in studying the bacterial content of wounds on which the solution was being used, devised a curve and its equation which applied to the rate of cure of a given area. It is certainly possible to observe the disappearance of the organisms by daily microscopic tests.

Many of the difficulties of administration and preparation are obviated by the use of a refinement of Dakin's solution, called Dichloramin-T, or Dakin Oil. This is a synthetic product, made with the idea of keeping the wound bathed constantly in the germicidal "chloramin," which, when formed in the administration of the original solution, rapidly disappears, thus necessitating the frequent irrigations. The whole subject of the "chloramin" treatment of infected wounds is unsettled, and it would be hazardous to venture an opinion on the merits of the Carrel-Dakin solution, but this much may be said: It is a distinct, and indeed, the only advance made since Lister in the treatment of wounds of this type. If its advocates can show that the healing is hastened, its use is not only warranted, it becomes a matter of necessity. If it is of value on an area in preparation for skin grafting, and it can be shown that the graft will "take" better for having been prepared in this way, it is eminently worth while. Even if it only serves to render less noisome the odors of the surgical wards, it seems to be an improvement over the ordinary salt solution or dry dressings. But authoritative statements on the subject are bound to appear in the near future, and within a year the matter will no doubt be settled. According to the reports from the war zone, it is one of the most promising discoveries of general surgery. Its use in civil life is another thing, and the reports from the large clinics are being eagerly awaited.

4. The use of the X-ray (Röntgenography).

In 1858-9, Gessler obtained a nearly complete vacuum within a glass tube and passed an alternating current through it. He removed all but 1/1000

part of the original "atmosphere," and observed that when the tube was "activated," or energized by the current, red, violet and blue rays were obtained. This is the principle of the so-called "violet-ray" machine of to-day. Ten years after Gessler had made his discovery, Hittorf studied the cathode (negative pole) rays in the vacuum tube through which an alternating current had been passed. Crookes, by means of a marked refinement of technic, reduced the vacuum to 1/1,000,000 of an atmosphere, and observed that when the conditions of Hittorf's experiment were reproduced, the cathode rays in striking the glass wall of the tube caused fluorescence. He made no attempt to explain the phenomenon. William Röntgen, in 1895, while working in his laboratory at Würzburg, accidentally discovered the so-called X-ray. He was experimenting with a Crookes tube, and after charging it, laid it down on a book. The book contained a key which he was using as a marker, and was lying on a plate-holder which contained some unexposed photographic plates which he intended using in taking some pictures with his camera. Kismet! A short time later, he made some exposures on the plates, and on developing and printing them he saw the key. The credit due him is on account of the fact that he knew "something" had occurred. He reproduced the conditions exactly as he remembered them, and obtained another picture of the key! The X-ray (as he called it) had been discovered. He later recognized that it was a form of energy.

Since then it has been found that the rays belong to the invisible portion of the spectrum (the lengths of the waves are too short to cause a

sensation on the retina), that they have a remarkable penetrating ability, being absorbed in proportion to the density and thickness of the substance through which they travel, and that some gas (in the tube) is necessary for their production. There are at present two chief forms of tube—the Coolidge and the Crookes, which differ in the method of production of the rays, and hence in the mode of distribution. The former is used almost exclusively in therapeutic work, but the latter, which permits of more accurate focusing of the rays, and hence great penetrability, is still used in obtaining the ordinary X-ray pictures (Röntgenograms, or radiograms) of the human body.

This instrument reached an unprecedented use in the recent war. Before 1914 it had obtained a wide use in the fields of chest diagnosis, examination of the intestinal tract, and fractures. The war added to this an enormous number of wounds containing foreign bodies (bullets, shrapnel, fragments of bones, etc.). The instrument is now one of the greatest accuracy. By taking exposures from two directions, the exact location of the foreign body may be determined. With great penetration and short exposure, the finest detail of bone structure may be brought to view. In obedience to the law we have mentioned, that the absorption is proportional to the density and thickness of the mass through which the rays pass, experts have developed the X-ray into an instrument of the finest precision in locating disease of almost every organ and tissue in the body. Stone in the bladder, tumors of the kidney, aneurisms, beginning malignancy of bone, tumors, intestinal adhesions and brain deformities from tumor, hydrocephalus, etc., are some of the

conditions which the expert Röntgenographer may now be able to diagnose with more or less certainty. Portable apparatuses were used during the war, permitting photography of patients too ill or uncomfortable to be moved to the X-ray laboratory. A great many enlisted men were trained in the technic of taking, developing and even interpreting the photographs. The best apparatus obtainable was in the hands of the U. S. Army Medical Corps, and the art of Röntgenography reached its highest development through the efforts of that organization.

5. Chemical warfare.

The Germans first used this most hellish of war's weapons at Ypres, against the English. Had it not been for a merciful whim of the wind which returned the flood of chlorine to its senders, or had the inventors of the idea realized its potency as a means of warfare, we might now have a far different map of Europe. Totally unprepared for this monstrous wave of yellow, choking fumes, the English morale would have been broken, and the Germans might have done as they pleased. To any one who has been in the chemical laboratory of high school or college, its odor and effect are well known. Fortunately, protection against it is easily afforded. It quickly combines with certain chemicals and forms harmless compounds. These chemicals were put into boxes (or canisters) and with breathing valves and tubes attached, were furnished to the soldiers at the front in ample time to prepare for the next gas attack. This protective mechanism later took the form of the now familiar gas mask.

But chlorine was the least of these "morale breakers," for as actual death-dealing implements, the toxic gases of chemical warfare were of only

slight efficacy. Later came "phosgene," which in even very dilute form produced edema of the lungs, lachrymation (excessive flow of tears), total incapacitation, and, if the concentration were great enough, death. Of the gases used by the Germans, however, the so-called "mustard gas" was at once the most potent weapon, and the most difficult to meet with mask protection. Added to the lachrymatory and pulmonic effects which phosgene afforded, there was the action of mustard as a skin irritant. Its burns are among the deepest, most permanent, and most difficult of treatment known. Small burns caused by mustard are not often painful, except as they become secondarily infected, but the slowly healing indolent ulcer may incapacitate a man for months. The problem of the treatment of such burns, the provision of adequate safety devices, and the necessary business of providing weapons of a similar nature to use in Allied warfare, was entrusted to the Chemical Warfare Service, a newly created corps of the army under the directorship of Major General William Sibert, with an experiment station at Washington and a demonstration station at the Edgewood arsenal, Maryland. Many members of the Medical Corps were assigned to special duty in the various divisions of the chemical service, especially in the research at the Washington experiment station. These men carried on researches of an unprecedented size and scope, and in collaboration with the best chemists the country afforded, helped to handle the protective and aggressive measures of chemical warfare in a splendidly successful manner. The press of the country has furnished us with much speculation concerning the invention of a new gas just before the Armistice

ended the World War. Whether there is or is not such a gas, it is presumably a military secret. It is a matter of public knowledge, however, that many new compounds were invented, tried experimentally on a few animals, turned over to the small scale manufacturers and produced. Pride would have us assume that at least one of these numerous inventions of American chemists was a worthy counter-weapon to use against a foe who had driven us to such extremes.

In France, each regiment had its "gas officer," and the whole subject of gas warfare was carefully studied by American scientists, medical and chemical. Gas masks were adjusted to such a nicety that they could be worn for hours at a time, though eventually, the glass or mica eyepieces dimmed with moisture, and the ever so light drag of the inlet valve became a burden to the muscles which lift the chest in inspiration, and the soldier must needs enter his "gas-tight" dugout (another safety device of science) for rest and food. The achievements of chemical warfare, both protective and aggressive, were primarily those of the American and Allied chemists, but physicians, physiologists, physicists, and pharmacologists contributed their modicum of knowledge applicable to the common end—to protect our soldiers and to "go the enemy one better."

6. Plastic surgery and the post-bellum care of the disabled.

It is a safe thing to assume that the aftermath of the recent war will have in proportion less of the disheartening and pitiable scars of conflict than those which have characterized any wars of history. Aside from the magnificent battle-front care of the

wounded, this probably depends on three things, the skillful plastic surgery of the day, the highly efficient prosthetic appliances, and the broad humanitarianism of the countries in treating and in caring for their sick and disabled, during the years following the signing of peace. The first of these is simply a refinement of principles already known in general surgery. But in the hands of specialists, the most marvelous results have been obtained in skin grafting, excision of disfiguring scars with the substitution of smaller and more hidden ones, removal of foreign bodies and bone fragments. Most of this work is now being done in the Eastern hospitals, such as the Walter Reed Hospital in Washington.

Aside from the scars of wounds healing after injury due to shrapnel and bullets, those of the toxic gases are probably the worst. Moreover, these are usually about the face and hands, have taken sometimes months to heal, and then heal with wide areas of scar tissue which has eventually contracted and greatly distorted the normal contour of the site of the injury. It is with these types of scars that the plastic surgeon finds his greatest success and an undying gratitude. Ears have been remade, and the rebuilt noses would have made Tagliocozzi envious—and proud that he was the first great cosmetic surgeon. Some of the facial skin grafts are really the best of their kind, and although sometimes these unfortunate cases need repeated operations, the results have changed many a man's future from a prospect of solitude for shame of his features into a normal active life, with only a mark here and there to remind him of his former wound.

The artificial limbs have been improved to a point of wonder. At first fitted with temporary appliances, the Government is now supplying the maimed soldiers with the best products of the prosthetic art. The writer has seen a man with both arms off at the shoulder doing carpentry worthy of a cabinet-maker. The amputated limb has left at times painful stumps, but by means of selective operations these have been practically obliterated and the tight-fitting limbs now in wide use permit the wearing of well-made clothes, and insure splendid equilibrium and locomotion.

Perhaps the most encouraging aspect of the whole idea of rehabilitation is the fact that the Government, and hence the people at large, are standing the expense. Soldiers wounded or sick in line of duty are cared for at the expense and under the supervision of the Public Health Service. There is a board for the vocational training of wounded or disabled soldiers, and at practically all of the larger colleges there are classes of men who come under the war risk insurance act, and who have been sent to these colleges at the expense of this board and its subsidiaries.

The hospitals of the Public Health Service are scattered over the entire United States. A soldier who claims disability incurred in line of duty has his fare paid to the nearest examining board. There his history is carefully taken, a complete physical examination is made, X-rays are obtained if necessary, dentistry is performed, every specialty is called upon for consultation, and a tentative degree of disability is decided upon. He remains at the hospital under no expense. If tuberculous he is sent to an appropriate sanitarium. If

surgery is indicated, the best surgeons available are obtained, and an operation is performed. If the treatment is medical, he remains at the hospital, there is a blissful absence of the old army discipline, he may come and go as he pleases, and he is visited every day by his ward physician.

Millions of dollars have been spent, and a limitless coffer is available for the treatment of such men. After all it is the only human thing to do, but remember, it was never attempted on such a scale before, and its novelty and its success are satisfying to the highest degree. The war has taught the world a good deal—it may soon be forgotten. But in science, nothing is forgotten. The lessons learned in medicine in this war will be ready for the next one, if such there be. If not, there are lessons of hygiene, sanitation, treatment of infected wounds, plastic surgery, and medical administration which are beautifully applicable to our everyday civilian life. In spite of its horrors, it is now as true as it was in the days of Ambroise Paré—"the place to learn surgery (and medicine) is on the battlefield."

We have purposely refrained from individual comment of living men. Medicine nowadays is so little affected by great discoveries of single men, that the historians of the twenty-first century may be at a loss to pick the greatest names from so many great ones. The art of healing is becoming the art of great masses of highly trained men. It is to be hoped that the perusal of this brief history of physicians and their art will give the reader some idea of the struggle against superstition, theory and the all but inexplicable problem of finding the causes of disease. You may search long and find no better

definitive precept of modern medicine than is contained in the first "Aphorism" of Hippocrates: "Life is short, and the art long; the occasion fleeting; experience fallacious, and judgment difficult. The physician must not only be prepared to do what is right himself, but also to make the patient, the attendants and externals cooperate."



Edward Jenner. M.D. F.R.S.

EDWARD JENNER



Lister

LISTER
(Sir Joseph, Baron Lister)

PART II

CHAPTER X

THE LIVING CAUSES OF DISEASE AND HOW THEY ACT; MICROORGANISMS

WE ARE surrounded on all sides by myriads of forms of life invisible to our naked eyes. Some of these are vegetable and others animal organisms. To these forms belong the germs. So tiny and so generally distributed in nature are these germs that the best milk obtainable, that is, the freest from contamination, contains over half a million of them in every teaspoonful and good milk over four million. They swarm on our skin and on every object of food or clothing. The air, water and soil are crowded with them. Our mouths and body cavities and our lower bowel harbor untold millions. The moment we scrape the skin from any part of our body, that moment do the germs and their spores multiply in the warm liquids of our tissues, and we have an infection.

But not all the germs by which we are surrounded are inimical to our interests and health, for our very lives and the lives of all animals and plants in the final analysis depend upon them. The decomposition of all dead forms is brought about by bacteria and the soil upon which plants depend for their food would be useless to them were it not for the nitri-

lying bacteria which form compounds of ammonia from the nitrogen of the air upon which the plants live. Even the rising of bread is due to bacteria, likewise the ripening of cheese, tobacco, etc. The masses of bacteria in the bowel are not usually harmful, since they split up and destroy substances which would otherwise be poisonous.

One of the greatest achievements of modern medicine was the discovery of germs and the creation of that department of science for their study which is called bacteriology. No branch of medical science has undergone more extensive development than this. None has contributed more to the happiness, comfort and well-being of mankind. The science of bacteriology has shown that certain bacteria are always detrimental to the health of man and tend to destroy his life. This class of microorganisms has been well named virulent, or pathogenic (disease-producing). Fortunately, the number of virulent germs, as compared with the nonvirulent, is small, but their number, notwithstanding, is large enough to constitute them a menace to the life of man, greater than that accruing from war itself. For far more people die of virulent infectious diseases than soldiers upon the battlefield. Indeed the terrors of war are infinitely multiplied by the ravages of these tiny enemies, so small that one bullet might afford a resting place for a number sufficient to infect a regiment of men. No wonder that all the energies of medical science should be turned toward devising a method for the destruction of these dangerous parasites, and that "no quarter" is the slogan of the contest.

Among the diseases caused by pathogenic germs of vegetable origin are pneumonia, typhoid fever,

epidemic cerebrospinal fever, consumption (tuberculosis), influenza ("flu"), diphtheria, cholera, lock-jaw, glanders, anthrax, erysipelas. Among those caused by germs of animal origin are malaria, amœbic dysentery, lues, and several tropical diseases. The so-called pus-producing germs represent an important class of virulent parasites which tend to produce inflammatory conditions in the body wherever they may be located. To this class of organisms we are indebted for a host of inflammations among which may be mentioned boils, carbuncles, abscesses, peritonitis, empyema, (pus in chest), rheumatism, endocarditis (pus in heart).

The tiny organisms of which we have been speaking have received the class name of bacteria. They assume different shapes and each species behaves in every way like a species of some higher form of life. For example, they usually breed true, although they are subject to variation. The tuberculosis organism, for example, since its discovery by Koch in 1882, has not changed in its special characters. It is by these special characters that all the different organisms have been classified. Some of the bacteria appear under the microscope like tiny round dots or points. To this class the name of coccus (plural, cocci) has been given. All the cocci are not perfectly round. Some are flattened into pairs, and these are called diplococci. Some are oval or lance-shaped. Some appear always in groups like a bunch of grapes; these are the staphylococci. Some appear in chains of different lengths one after the other, in Indian file, in straight line, or sinuous course; these are called the streptococci. Some of the bacteria look like short rods or sticks; these have been called bacilli. Some are curved; these are spirilli, etc.

Sometimes ordinary yeasts and molds may be virulent (disease producing). Thrush is a disease of babies' mouths caused by the growth of a mold.

Diseases which are caused by a special kind of virulent microorganism or bacterium, are known as specific diseases. The way in which it has been finally determined that a special germ causes a special disease is not alone to observe its constant presence in the particular disease, but to actually cultivate or grow the germ on artificial media outside the body, to separate it carefully from other or contaminating microorganisms until a so-called pure culture is obtained, and finally to inject it into a susceptible animal and reproduce the disease as often as is desired. On this basis Koch formulated his famous postulates which have come to form the philosophical foundation of bacteriology and bacterial pathology.

Now the simple presence of a germ in the tissues of the body does not constitute in itself the most important part of an infectious disease. There is another feature. This is the fact that germs during their growth appear to secrete some kind of chemical substance different for each bacterium which is of a poisonous nature. This substance is called a toxin or specific toxin. Some of these toxins which seem to be of the nature of ferments can be obtained separate from the organism like the juice of a plant. An example is the diphtheria toxin which can be extracted in abundance from the diphtheria germ. Other toxins appear to be so firmly bound up with the bodies of the germs that they cannot be separated from the organism itself without drying and grinding it up; for example, the pneumonia germ. Such are called endotoxins.

This difference is not entirely of an academic interest, but has a practical value. In the case of the diphtheria germ the poison or toxin can be separately secured and injected into animals for the purpose of obtaining an antitoxin from the blood of the animal injected. This antitoxin as is well known can be successfully used for the prevention and cure of this dreaded disease in human beings. In fact, diphtheria antitoxin has robbed this disease of three-fourths of its terror for the human race.

Virulent germs are constantly gaining access to our body tissues and this question immediately arises therefore: how is it that any of us escape the ravages of these germs? The complete answer to this question as far as it is known would require a volume and will be dealt with more at length under the next heading, but it may also be answered in a word and that word is resistance. The body tissues resist by virtue of inherent or developed powers and rise as it were in their might to destroy the invaders. The germ finds a lodgment. The tissues resist. The battle is on and the result is either victory or defeat for one side or the other. The resistance of the tissues is carried on principally in two ways. First by the chemical powers of the body fluids, cellular and intracellular, including the blood, and by the actual devouring capacity of certain cells of the body, like the white corpuscles of the blood and certain cells (endothelial) which line all the interstices and cavities of the body. Were it not for these resisting powers we would fall an easy prey to the invasion of germs. While the battle above referred to goes on, if the germs are present in any considerable number or are so situated and entrenched

that the resisting forces of the body cannot quickly destroy the invaders, certain phenomena occur of a striking character. The infected individual shows certain symptoms, as we call them, of infection. He is sick. He has we say an infectious disease. If the germ invasion happens to be confined to one spot we say there is a local infection. If the germs get into the blood and are carried generally throughout the body we call the condition a septicemia. If pus germs are present a local abscess may be formed in the one case or a general pyemia (pus in the blood) with multiple abscesses in many organs of the body in the other.

The place in the body where infectious germs find entrance is called a "portal of entry." These portals are various, for pathogenic germs may enter from a variety of points. The skin, tonsils, nose, lungs, intestines, are favorite ports of entry. The typhoid germ gets in through the bowel. The germ of consumption usually through the lungs. If the germs obtain a foothold in an organ and succeed in entrenching themselves so that the natural resistances cannot destroy them, but can only hold them in the original location, still errant germs may accidentally find their way into the circulation and the toxins may seep into the blood more or less continuously from their point of formation and do damage. Such an infected locality has received the name of "focus of infection." Local infections from teeth, tonsils, gall bladder, middle ear, large intestine, urinary or other organs are receiving much attention at the present day and the search for and removal of such foci upon which many general diseases and much ill health are supposed to depend constitute one of the principal duties of the present-day physician. So

important is this subject of foci of infections and focal infectious diseases that more will be said about it in a subsequent chapter.

Naturally in a book of this nature the description of all the individual pathogenic germs which are known cannot be attempted. Such information is obtainable in books on general or descriptive bacteriology.

Now, besides the pathogenic microorganisms of vegetable nature which we have just considered as causes of some of the most common as well as the most terrible diseases which afflict human beings, we have also to consider briefly a second class of microscopic parasites which are also pathogenic (disease-producing). This class is that of tiny animal organisms. These minute microscopic animalculæ belong to the lowest class of animal organisms known as the protozoa. It is not quite so easy to study these minute forms of animal life as it is the vegetable forms, for they are more difficult to grow artificially. The number of diseases known absolutely to be caused by animal parasites is not so great as those which are known to be caused by tiny vegetable forms or bacteria. But their numbers are increasing and will probably grow as refined methods of study are developed.

Amœbic dysentery, malaria, African sleeping sickness and lues have been demonstrated to be caused by animal parasites which have been definitely determined. Furthermore there is an important class of animal parasites which, although their eggs or spores are microscopic, grow in the adult stage to be visible to the naked eye. To this class belong trichina, hookworm, and the common parasites of

the intestinal tract included under the general head of "worms," of which the roundworm, the tapeworm and seatworm are the best known in temperate latitudes.

Finally, it is supposed that smallpox, scarlet fever, yellow fever, measles, infantile paralysis, rabies and some other communicable diseases are due to living germs, though the absolute demonstration of the microorganisms is still forthcoming. The difficulty here is that the parasite is so minute that it is barely visible or totally invisible under the highest power of the microscope. The name of ultramicroscopic has been applied to these incredibly small organisms. On account of the fact that they are able to pass through the pores of porcelain filters small enough to hold back all ordinary bacteria, they are spoken of also as filter passers or filterable viruses. Some of these organisms are probably bacteria, i. e., vegetable, while others are undoubtedly protozoa, i. e., animal; although we can only surmise their biological relationship. One of the best examples of a filter passer is the virus of yellow fever. It was not until the epoch-making investigations of the American Yellow Fever Commission in Cuba that the true nature of the cause of yellow fever was discovered. Its transmission by the mosquito was also demonstrated. The names of Reed, Carroll and Agramonte were made immortal by the discovery and by the fact that all three practically martyred themselves in the pursuit of their investigations.

Another filter passer of great importance in human pathology is the germ of infantile paralysis (poliomyelitis) discovered by Flexner and his co-workers at Rockefeller Institute.

PORTALS OF INFECTION

The first problem in regard to parasitic diseases is to determine just how the germs gain entrance into the body. The new-born child is entirely free from germs as a rule, both the skin and alimentary canal being sterile. Soon after birth germs gain entrance into the intestines and remain there in large quantities throughout life. Bacteria are numerous in the mouth, few in the stomach on account of its acidity, and gradually increase in number in the intestine until in the large bowel their number is legion. One popular theory in respect to old age (that of Metchnikoff) incriminates these bacteria in the large intestine as the source of poisonous material which, absorbed into the blood, is supposed to produce the degenerative changes in the tissues characteristic of senility.

The tissues of the body are well protected against the invasions of germs. The external surface of the body is covered by a thick layer of skin, which is made up of layers of epithelial cells, affording perfect protection as long as these cells remain intact.

The skin is normally covered with bacteria on all parts of its surface and this fact makes the sterilization of the skin as a preparation to surgical operations a difficult matter. A few organisms are able to penetrate the unbroken skin. An example is the embryo of the hookworm, another the germ of epidemic jaundice which causes disease in miners and spread among soldiers in the trenches during the late war. Friction of the skin may succeed occasionally in introducing the germs of acne, boils and pimples into the skin. Ordinarily however an actual

break in the surface is necessary to enable the organisms to penetrate to the deeper tissues. Trench fever infection during the war was found to gain entrance through scratch wounds as well as the bites of lice.

The epithelial lining of the alimentary tract forms a protective mechanism against the entrance of germs similar to but not so effective perhaps as that of the skin. Into the mouth and nose germs are continually introduced from without in food, drink and air. The accumulation of food about the teeth provides a suitable medium for the growth of germs and consequently the necessity of keeping the teeth carefully cleansed of food remains. Besides this the opportunity for injury of the epithelium covering the gums are numerous, from the time of the eruption of the teeth, and consequently it is not to be wondered at that the teeth and gums, harboring as they do foci of infection and germ life, have come to be regarded as the cause of pyorrhœal (tooth-gum) inflammations and from this thought it is not such an extraordinary stretch of the imagination to regard these foci of infection as the source of passage of germs into the general tissues, with the production by them of numerous forms of general disease. Equally important with the teeth as gateways of infections are the tonsils and nasal sinuses. Through the mucous membranes of these regions it is believed that the germs of meningitis and infantile paralysis gain entrance. The respiratory tract (bronchial tubes) is defended normally both by epithelium and by small cilia, or hairlike prolongations, which brush all foreign bodies toward the mouth through which they are expectorated embedded in mucous.

THE MECHANISM OF BODILY RESISTANCE
TO INFECTIONS

Although in a preceding sub-chapter on the living causes of disease (microorganisms) something was said incidentally about the way in which our bodies resist the inroads of microbic infection, this subject is of such transcendent importance that it must be considered more in detail.

There is no more important knowledge to be grasped by the study of medical philosophy than that which relates to an understanding of the mechanism by which the animal body protects itself against its numerous living though microscopic enemies. The most astonishing triumphs of preventive and curative medicine have thus been obtained.

Bodily resistance, insusceptibility, intolerance or immunity are words which express the varied organic mechanisms whose end is to defeat the insidious inroads of infection. We have endeavored to point out the great importance of that group of diseases in which the cause is assumed to be an infection by some external animate organism. It has been said that one-half, at least, of all known diseases are referable to agents of this nature. There is no question therefore as to the relative importance of infectious diseases in consideration of diseases as a whole. Infectious diseases as a class have been so intensely studied in recent years that they have become better understood than the noninfectious class. These studies have led in a number of instances to practical results of great value in diagnosis, prevention and treatment. A new science has sprung up as a result of these researches, which

is the science of prevention of infectious diseases and this science is called Immunology.

Although the infectious diseases are due in each instance to the entrance, extension and multiplication in the body of some living microscopic plant or animal, i. e., bacterium or protozoa, many of the conditions produced by the microorganisms are simply due to the fact that they are composed of a so-called foreign protein (albumen). It is a well-known fact that all of the numerous proteins which we eat in our food are broken up by the process of digestion into simpler bodies (amino acids), which are absorbed into the blood and are finally built up or reconstructed into the substances of which our tissues are normally composed. Now if any of these protein substances (such as egg, milk, meat) be injected directly into the tissues or circulation they may act as poisons. It appears to be the same with bacteria, which, if taken into the alimentary tract, may be digested and even absorbed without harmful consequences, while if they gain entrance to the tissues directly, parenterally as it is called technically, they set up a series of toxic, i. e., poisonous reactions which constitute the phenomena of infection or an infectious process. The response of the body to an infection may result in one of two eventualities. Either the infected individual as a result of the ravages of the disease dies or he gets well. Now in the latter event a strange or subtle transformation on the part of the individual is found in many cases to have occurred. He becomes immune, as we say, to a subsequent repetition of the disease. He does not "take" it again as it is said in ordinary speech. How is this wonderful phenomenon produced? In recent times much experimental work has been done to find

the answer and much philosophical speculation has been offered. It will be impossible in the limits of this book and might perhaps be wearisome to the general reader to go into great detail. For practical purposes it may be generalized, that during the struggle which takes place in the tissues following the introduction of disease-producing microorganisms certain antagonistic substances known as antibodies are formed. For instance, if an individual contracts typhoid fever and recovers, antibodies are gradually formed in the blood and tissues during the course of the disease and these antibodies effectually prevent or tend to prevent the development of typhoid germs in that individual during the rest of his life.

Any substance capable of producing antibodies in the animal body is known as an antigen. The only substances known to possess antigenic properties are proteins (albumens). Other substances like starches and fats do not seem to possess the property. Closely linked with the antigenic property of proteins is the fact that each individual protein or antigen forms individual or particular antibodies for that substance. That is there is a "specificity," as it is called, in the reaction; the typhoid antigen forms a typhoid antibody only; similarly the diphtheria "antigen" forms a diphtheria antibody only, and a person who is immune to typhoid fever as the result of the accumulation of typhoid antibodies in his blood is not protected thereby from a diphtheritic or other special infectious disease (antigen). The animal body possesses an elaborate mechanism for preventing the entrance and extension of pathogenic (disease-producing) microorganisms. Even when such a germ has obtained a hold upon the tissues of a host (person), sufficient to produce local or general

symptoms, the body immediately proceeds to resist its further advances. As has been said above, the phenomena which follow may be likened to a battle, the outcome of which will depend upon the relation established between the contending forces. It is a matter of common observation that certain infectious diseases characteristic of one species of animals will not be found in another. One species will be found to be insusceptible to the common diseases of the other. Such a condition of relative natural resistance is often called a species or racial immunity. For example, warm-blooded and cold-blooded animals differ remarkably in their susceptibility to infectious diseases. Lockjaw never affects a cold-blooded animal, and even those diseases like tuberculosis, which appear to be found in both, differ markedly in their characteristics. Birds and animals, carnivora and herbivora, have their special infectious diseases. Man has many infectious diseases common to him alone and which cannot be transmitted readily to lower animals except under special circumstances. The manlike (anthropoid) apes appear to be more nearly related in their susceptibility to human infectious diseases than any other animal and this is supposed to be due to the biological relationship or species nearness between the two.

When a person contracts an infectious disease like typhoid fever or diphtheria and recovering, acquires through processes above mentioned an insusceptibility to a subsequent attack, we say that he has developed an "acquired immunity." It has been noted, ever since diseases were identified and separated into different classes, that persons who had recovered from certain infectious diseases were not liable thereafter, or only rarely liable, to a recur-

rence. They were immune. This was found to be particularly true of the "rash" diseases, scarlet fever, chicken pox, and smallpox, also to mumps, typhoid fever, plague, cholera, yellow fever, typhus and infantile paralysis (poliomyelitis). It was also found that there are other infectious diseases such as diphtheria, lues, tuberculosis, pneumonia, influenza, glanders, blenorrhagia, dengue fever, recurrent fever, lockjaw (tetanus), pus infections and erysipelas in which a durable immunity does not usually occur or is difficult to obtain. It is believed, however, that even in this latter class of diseases, an actual immunity does exist for at least an appreciable length of time. The phenomenon of acquired immunity to diseases has been not only noted for centuries, but has, ever since the time of the ancients, been utilized in a practical way. Individuals who had recovered from plague, smallpox and yellow fever were from time immemorial employed as nurses in hospitals where these diseases were treated. Efforts to imitate nature and procure an artificially produced immunity date from long ago and have not been confined to highly civilized peoples. The best instance of an artificial immunization against infectious diseases is naturally that of smallpox. The Chinese and East Indians have practiced it, as is known, since the eleventh century by inserting the scabs of smallpox postules in the nose or by actually inoculating the arm. The method was introduced into England by Lady Mary Wortley Montague in 1781 and was practiced there in a casual way until the introduction of vaccine by Jenner in 1798.

This great discovery, whose popularization was due to Jenner, marks an epoch in the history of

medicine as it does also in that department of therapeutics (treatment) of infectious diseases which deals with artificially produced immunization. It had been noted that milkmaids, who handled the teats of cows suffering from a pustular eruption known as cowpox, frequently acquired similar pustules on their hands and it had been further noted that individuals so infected failed to contract the human disease, smallpox, in times of epidemics. These facts formed the basis for Jenner's observations, experiments and speculations. Mention has already been made of Jenner's great discovery in Part I of this book. No further progress in protective inoculation against infectious diseases was made from the time of Jenner until the work of Pasteur on chicken cholera in 1879. Pasteur found during his experimentations, that if he allowed cultures of chicken cholera to become old and attenuated, they lost a part of their virulence and that he could inoculate fowls without producing a fatal outbreak of the disease, and stranger still he found that those fowls injected with these weak cultures were thereafter protected from the injections of virulent germs of the disease. Pasteur had, as it were, rediscovered the principle of Jenner. By a similar method Pasteur was able to prevent the diseases anthrax in sheep and erysipelas in swine. The same principle has since been utilized in preventive immunization against typhoid fever, cholera, plague and pneumonia.

It would be out of place in a work of this character to enter deeply into a discussion of the various theories that have arisen to account for the facts of immunity. Some of them have been fantastic indeed and many are the terms which have been in-

vented to designate different hypothetical substances involved in the process, which terms at the present time have, as it were, a historical meaning only. Nevertheless, so interesting have some of these theories been that apart from the fact that they have had a decided influence in shaping the course of scientific investigations, it would be necessary to mention them. One of the most celebrated hypotheses constructed to explain the phenomena of immunity has been that of Ehrlich. We say has been, because this theory advanced by the great German scientist and upheld by a host of collaborators and followers has at the present day less hold upon the convictions of medical men than formerly. Nevertheless, it can be said that no theory, or better, no hypothesis constructed to illustrate the intimate mechanism of a biological process, ever had more ardent and vigorous supporters than this. It was however preceded chronologically by the hypothesis of Metchnikoff and the first battle waged in the great philosophical polemic on the explanation of immunity phenomena was waged between the advocates of these two hypotheses. We will give a brief account of this controversy.

Metchnikoff's so-called theory of "phagocytosis" was the first experimentally substantiated and complete explanation of immunity. Metchnikoff, after a series of long experiments, announced his conclusion that the most important and perhaps the solely important factor which the body possesses for defending itself against microorganisms of disease is the power of the leucocytes or white corpuscles of the blood to destroy the invaders. This destruction, he showed, was carried out by an active process of engulfing and destroying the germs by digestion. This process of eating up the germs, as it were, he

called "phagocytosis" and the cells which did the eating "phagocytes." According to Metchnikoff the chief protective cells are the white corpuscles of the blood, particularly those with complicated deep-staining nuclei, known as polynuclear leucocytes. These cells constitute about 75 per cent of the total number of white blood cells. Besides these cells, Metchnikoff found that another type of white blood cell, larger than the above and with a single round nucleus, also possessed "bacteria eating" (phagocytic) power, but to a lesser degree or of a different type. Finally Metchnikoff found that other cells are likewise endowed; especially certain cells not in the blood, but fixed in definite situations in the body, notably the bone marrow and interstices of the tissues (endothelial type). The paramount thought in Metchnikoff's conception of phagocytosis was that the whole process of immunity is a simple adaptation of a digestive process for the purpose of protection against foreign cells. According to this theory, therefore, all immunity is cellular in nature.

The next theory to develop was humoral in nature. Practically coincidentally with the beginning of Metchnikoff's theory of immunity, which was developed in France and which may be said therefore to be a French theory, there arose in Germany a school which opposed it. Certain investigators, notably Buchner, found that bacteria could be destroyed by certain tissue juices, especially blood serum, apparently without the intervention of any living cellular activity at all. Buchner claimed that the bactericidal action of blood is due to the blood serum and he attributed the activity of the serum to the presence in the blood of substances which he designated as alexines (from a Greek word mean-

ing to ward off or protect). He found that he could destroy these alexines by heating them to 55 degrees centigrade. He regarded these alexines as ferments. They were later considered to be derived from the white cells of the blood. It will be seen that there was a harmony after all between the two apparently divergent views. Other investigators, notably Pfeiffer and Bordet, found that the substance called alexine is present in the blood serum of all animals, but that when a poisonous germ is injected into a susceptible animal, a substance is formed in the blood serum which is always specific for the particular germ used. This substance is a true antibody and tends to attach itself to the germ and render it "sensitive" as it were, to the action of the destroying principle or substance of the blood serum (i. e., the alexine). Inasmuch as this sensitizing substance prepares the germ to be dissolved it is called a lysin. The destruction of bacteria in the blood is thus brought about by two substances, a "sensitizer" or lysin, which varies in each case with the particular germ which is acting, therefore specific, and a bactericidal substance or alexine present normally in the serum, but which does not develop its true or maximum power in the presence of a particular germ until a special sensitizing substance for that germ has been formed.

All the phenomena of immunity depend therefore upon the play of these forces; the germ (or antigen), the sensitizing substance (or lysin) and the bacteria-destroying substance (alexine). It will be impossible to go into detail concerning Ehrlich's views with regard to the manner in which these forces act. He gave special names to the three substances mentioned above which will not be men-

tioned, because of the confusion which a multiplicity of names would give. Besides this, the rather fanciful and complex mechanisms which he invented are not calculated to clarify the situation and no longer carry the weight they did a generation ago. It may be stated, however, as a fundamental proposition, that Ehrlich taught that all these reactions are of a definite chemical nature, resembling such a reaction as takes place between an acid and a base. According to Bordet they are physicochemical in nature and more to be compared with the action of a dye-stuff. To go further into this interesting subject would carry us too far afield.

ANAPHYLAXIS OR HYPERSENSIBILITY

We come now to a discussion of a peculiar condition that is intimately bound up with the problem of immunity. This is the condition that had been named hypersusceptibility or anaphylaxis. It has been long known that certain individuals show symptoms of acute poisoning from eating eggs, strawberries, etc. Others develop severe irritation of the nose or bronchial tubes or both (hay fever, hay asthma) when they are exposed to breathing air containing the pollen of certain plants. Finally, some persons are made extremely ill by the injection of various sera, such as diphtheria antitoxin. The symptoms in such a case may be sudden and acute, accompanied by vomiting, shortness of breath and collapse, or may be delayed and consist of fever, pains in the joints and rash. To Richet (1905) a Frenchman, we owe the scientific demonstration of and the name anaphylaxis. He showed that animals were rendered much more sensitive to injection of certain poisons by having received a previous dose. He

named the condition anaphylaxis to contrast it with the opposite state of prophylaxis, or immunity.

Anaphylaxis may show itself by local as well as by general signs. That is, the place where the injection is made in the sensitive animal may become inflamed and show signs of marked irritation. But it is the general phenomena which are more interesting and striking. The phenomena can best be shown in the guinea pig. A very small amount of some protein substance, whether it be from bacteria or from some ordinary substance, such as milk or white of egg, etc., will, if injected into this animal, bring about some subtle physiologic changes in the organism so that a subsequent injection, after a certain lapse of time, of the same proteid, will set up a dramatic situation in which the animal may expire. The animal becomes excited, has great shortness of breath and finally becomes paralyzed or dies by asphyxia. Now anaphylaxis is as specific as immunity. By this is meant that an animal sensitized to one protein reacts only to the same protein.

The extreme symptoms which occur so regularly and dramatically in the guinea pig are not by any means found to an equal extent in other animals. Nevertheless, a similar if not identical reaction may be found. Animals that recover from "anaphylactic shock," as the symptoms are called, are for a time thereafter insusceptible to re intoxication by the protein by which they had been sensitized. They are said to be in a refractory stage. This fact has a practical application in human medicine, for it is necessary to be sure before giving large amounts of diphtheria antitoxin (horse serum protein), to take special measures to determine whether such an individual is sensitized to the serum and if so to bring

about a desensitization. This desensitization is effected by giving small amounts of the serum hypodermically prior to the final injection.

Numerous theories have been devised to explain the wonderful phenomena of anaphylaxis, but the general complexity of the subject itself and the lack of unanimity of authoritative sources will preclude any but a brief mention of this phase of the subject. Early observers were inclined to regard the reaction as simply one in which an antigen produced an antibody, just as is supposed to be the case in ordinary immunity reactions. Undoubtedly this is partly the case, but some explanation of the alarming symptoms must be found and the most probable one is this: When an animal is sensitized, as it is called, by the injection of a foreign protein into his tissues or blood, nature reacts by forming a considerable amount of a digesting ferment adapted to the digestion of this protein. Now if another dose of the protein is injected while the ferment is present, the protein will be rapidly split up on its second injection into the body and elements are set free which are poisonous in their nature. This hypothesis was originally advocated by Vaughn of Ann Arbor and has received the indorsement of many at the present day. Other theories, some of great plausibility, have also been proposed, but limitation of space forbids details. There is undoubtedly some close relation between anaphylaxis and immunity. The wasting process of chronic diseases and even the phenomena of fever itself have been explained by some as being due to the same essential process as that upon which sensitization depends.

In human beings there are three generally accepted types of anaphylactic phenomena. First, the

so-called "serum sickness" in which a hivelike rash, fever and joint pains follow an injection of some type of serum. Secondly, there is the local variety in which an inflammatory reaction appears at the site of the injection. Thirdly, the so-called guinea-pig type of reaction or acute anaphylactic shock. This last is characterized by shortness of breath, blueness of the face or extremities, nausea and occasionally, though fortunately rarely, death.

Many applications of the facts and phenomena of immunology to the diagnosis, prevention and treatment of infectious disease have been discovered. Although the abstract considerations which have been outlined above are interesting in a high degree they become far more thrilling when viewed from the standpoint of their practical utilization. So extensive is this field of medical endeavor that to consider it adequately would require a volume. First, as to the diagnosis of diseases by utilizing the facts and the theories of immunity. Much has been done in this direction. The identification of a suspected germ is one of the important uses to which certain sera can be put. Thus the diagnosis of typhoid germs may be made by taking the serum of a patient known to be suffering from the disease and noting an agglutination or clumping of the germs if they are in reality typhoid germs. A second useful application of reactions of this sort lies in the determination of the causal relationship of an organism that is suspected to produce a certain disease by testing it with serum from patients who are known to have the disease.

Thus in the case of a particular germ (a cocci-bacillus) suspected by its discoverers, Bordet and

Gengou, to be the cause of whooping cough, it was found that this germ reacted in a definite way with the blood serum of cases of the disease and thus its causal relationship was proven.

Finally, tests of this sort are useful in differentiating bacteria which are closely related. Thus the various strains of pneumonia germs have been separated in this way so that several types of this dangerous parasite have been individualized, their relative dangers estimated and some progress made in developing a serum for treatment. The germ which causes the dreadful malady known as cerebrospinal meningitis has been similarly divided into types by this means.

Another important class of test includes the opposite method of determining the presence of antibodies in the serum of a diseased person, thus assisting in the recognition (diagnosis) of certain infectious diseases. The value of these tests in these cases depends upon the fact that if the blood serum of a person suspected of having a certain infection as, for example, typhoid fever, be mixed with a culture of typhoid germs, the germs will be agglutinated or clumped together. As applied to typhoid fever, this is the so-called celebrated Widal reaction. The agglutination reaction is of particular value in the diagnosis of typhoid fever, paratyphoid fever, Malta fever and relapsing fever. Very important in medical diagnosis also are the tests dependent upon local reactions produced in patients by injecting an extract of a germ suspected as causing disease in the individual to be tested. This reaction is known technically as allergy and is made use of especially in the diagnosis of tuberculosis, in which disease the germ extract (tuberculin) is

injected into the skin or even applied to the mucous membrane of the eye.

The subject of the prevention and treatment of infectious diseases by the use of antigens and antisera is a very large and important one. We can only summarize in our limited space the instances in which serums and vaccines are used successfully in preventing and curing these diseases.

The first and perhaps the most completely successful instance of prevention of disease by vaccination is that of smallpox, which has been heretofore described. It appears to have been demonstrated, that in countries where vaccination is practiced twice in a lifetime, smallpox has practically disappeared. How much general improvement in hygienic conditions of life have had to do with this remarkable conquest of a dreaded scourge, it will be impossible to state, but the fact that vaccination has been a powerful factor in the same direction would appear undeniable. Another example of fairly successful vaccination against a terrible infectious disease, may be cited in the case of typhoid fever, which seems so rare at the present time that cases of the disease are few and far between, even in general hospitals where ten years ago cases were extremely numerous. The method even when consistently carried out does not always succeed. Even in troops during the World War, who were considered to be entirely immune by virtue of vaccine prophylaxis, cases of typhoid fever and even small epidemics occurred. The duration of the prevention is at most limited to a year or two. The use of a dried virus in hydrophobia has, it is claimed, since its discovery by Pasteur reduced the mortality from this disease from 15 to less than 1 per cent.

The interest in vaccine therapy was greatly stimulated a few years ago by the work of Sir Almroth Wright, who popularized the use of so-called autogenous vaccines, that is, vaccines made from actual germs cultivated from the tissues or blood in certain diseases. In this method, the germs are killed and injected in quantities of millions for the purpose of attempting to produce artificially an increase in the natural resistance of the patient. Local infections have been most benefited by this method, especially pus germs (*staphylococcus*), infections of the skin.

Tetanus (lockjaw) antitoxin is the best example of an effective use of immune serum in prevention. Lockjaw appears to have been greatly diminished, especially after the Fourth of July accidents, since its introduction. Another example is the prevention of gas gangrene. Diphtheria antitoxin is also valuable as a preventive agent, but the prophylaxis lasts only two or four weeks. The use of diphtheria antitoxin still remains the most conspicuous example of antiserum therapy. Its use is credited with reducing the mortality from this rightly feared disease from 40 to 10 per cent. It is claimed that if the antitoxin is used on the first day of the disease, the mortality is zero. Another striking example of a useful antiserum is that introduced by Flexner in the treatment of epidemic cerebrospinal meningitis. The mortality from this disease, it is said, has been reduced from 80 to 30 per cent. Here the serum is injected directly into the spinal canal.

FOCAL INFECTION AND FOCI OF INFECTION

The terms focus of infection and focal infections are much in use at the present time among medical men and even the general public is taking an in-

creasing interest in the things which these terms denote. By focus of infection is meant a localized or circumscribed area of tissue invaded by pathogenic, namely, disease-producing microorganisms. By focal infection or perhaps more correctly focal infection disease, is meant a disease of the body as a whole or any part of the body due to infectious microorganisms carried in the blood or lymph stream from a focus of infection. A focus of infection is called primary when it represents the first or original situation at which the germs acquire a foothold. Other foci of infection set up by this first one are called secondary foci.

A focus of infection may be acute or chronic; that is, it may produce when acute, or first formed, certain signs of inflammation located in the infected part, or may tend to slumber for a long time with or without local manifestations, in which event we say it is chronic. Primary or early foci of infection are usually located in parts of the body connected with its surface; namely, skin and mucous membrane, because it is in these situations naturally that infectious germs originally gain entrance. The commonest sites are about the head, especially the mouth, throat, nose, and nasal sinus cavities, and the ear, for these parts are constantly the habitat for great numbers of different germs. In the mouth it is the teeth which are a frequent seat for primary foci of infection. Caries or decay of the teeth and pyorrhea of the gums, which are so frequent, give ample opportunity for the ingress of germs in this locality. The tonsils are full of crypts and so are the sinuses of the nose full of minute spaces where infectious germs may set up inflammations under favorable circumstances and

thus gradually form foci of infection. The presence of overgrowth of the so-called lymphoid tissue which composes the tonsils and adenoids increases susceptibility of these parts to invasion of germ life and consequently to the formation of foci of infection.

The air passages such as the larynx (organ of voice), the trachea (windpipe), the bronchial tubes and lungs are not so frequent sites of foci of infection as the parts above mentioned, but nevertheless may be the occasional source of spots of infection from whence germ life may seep into the blood stream (bacteriemia) and thence to the body generally. The whole alimentary tract from the mouth to the rectum has to be reckoned with especially, in respect to the possibilities for the location of foci for infection. The importance of the gums and teeth has already been alluded to in this regard. But the intestinal tract, especially the large intestine, looms large in importance. Slowing of the passage of the bowel contents, so-called intestinal stasis, may give rise to local infection of the bowel wall under certain circumstances, and inflammation of the gall bladder and appendix which have become chronic are looked upon as frequent examples of infectious foci. Then, too, the urinary tract and genital organs have been justly incriminated as situations in which foci of infection are frequently lodged and from which the slow and chronic processes of general bodily infection or poisoning may result. The pathogenic or disease-producing germs which develop in these various locations or foci above mentioned are numerous indeed, and no attempt will be made to enumerate them. But at the head of the list come the different varieties of the

so-called pus-producing germs; among which the most important are the so-called string-shaped coccus or streptococcus, which has many strains, among which, on account of their especial importance, may be mentioned the blood-destroying germ (streptococcus hemolyticus), the rheumatism-producing pus germ (*S. rheumaticus*), etc. Catarrh-producing, pneumonia-producing, and abscess-producing germs are likewise in this category. All of these different germs and many others have actually been cultivated by bacteriologists from foci of infection in the mouth and elsewhere. In special localities like the intestinal tract and genito-urinary organs, special kinds of germs are found along with the ordinary pus-producers, and it is not at all uncommon in every situation where foci of infection may be formed to find several kinds of germ life intimately associated and growing together (symbiosis).

Of course it must not be understood that every person who gets an acute infection, say of the tonsils, will develop a chronic focus of infection in that part, or that such a chronic focus if once formed will lead inevitably to the development of general or systemic disease. Many persons, of course, have tonsilitis, or tooth abscesses or sinusitis, or middle ear inflammation and promptly recover. It is rational to presume under these circumstances, that the character of the germ is not excessively virulent or what is equally likely that the natural defenses of the body are sufficient to overcome the invaders in a short period of time. On the other hand, some peculiarly poisonous attribute of the germ or some temporary diminution of the resisting forces may enable the germs to gain entrance to the body and set up trouble in some other and distant

organ such as the joints, lining membrane of the heart, the kidneys, or brain. There is in some cases a sort of selective affinity whereby a special germ when it gets a chance will pick out a certain organ in the body upon which to pounce as it were and do damage.

The recognition of foci of infection in certain situations may be occasionally made by mere inspection, as when the teeth are seen to be decayed and pus is seen exuding from the gums (pyorrhea). But chronic abscesses and infections at the root of a tooth can only be diagnosed with certainty by the use of the X-ray and consequently at the present time, it has become a routine practice to radiograph some or all of the teeth sockets in every case where the symptoms point to the possibility of the existence of focal infection disease. The question of the diagnosis of foci of infection is one of exceedingly great importance to the physician, but its complexity and the multiplicity of detail preclude any further discussion of it.

Now, how are the infectious microorganisms and their products, located or elaborated at a focus of infection, disseminated into the general system? It has already been hinted that there are two principal routes. One is by the way of the blood vessels, the other by way of the lymph. In the first of these, the germs get into the small veins or capillaries and finally into the main blood current itself, by which they may be carried to any place in the body. Their ultimate location in another part depends upon a variety of circumstances, which it cannot be said are very well understood at the present time. The second way by the lymph stream is naturally into the lymph glands, which barrier of defense the

germs must pass to gain entrance to the body generally. The poisons secreted by the germs may gain entrance to the body through either of the above channels and naturally easier than the bacteria themselves. But in this connection the germs are more important than their toxins. Another interesting phase of the subject of focal infections arises from the fact that germs and their toxins, being of the nature of protein or albumenlike substances, their introduction into the general system may give rise to phenomena of sensitization or anaphylaxis, a subject which has already been discussed. Bronchial asthma is a disease which in late years has been attributed, at least in some of the cases, to a foreign germ-protein elaborated from some focus of infection located somewhere in the respiratory tract. Acute articular rheumatism or rheumatic fever is a disease which is now considered to arise often from foci of infection. Very often this focus is located in the tonsils. The relation of tonsilitis to rheumatic fever has been a matter of common observation and noted for years. Practitioners of medicine for decades have recognized certain types of tonsilar infection as rheumatic in nature and have found that the same drugs which are effective in the one are effective in the other. The tonsilar infection which is the source of rheumatic fever may be an ordinary acute attack, but more often is chronic in tendency and even so mild in itself that little attention is paid to it. The germ of rheumatic fever is now recognized as a microorganism of a round shape which may vary considerably in this respect and in other characteristics. It is now called the small coccus or streptococcus rheumaticus. This germ growing, we will say, in some focus in the

tonsil acquires a certain special tendency to produce rheumatism. One attack of rheumatic fever does not confer immunity or protection against subsequent attacks, indeed the susceptibility to subsequent attacks is increased. Experience has shown that a thorough eradication of a focus of infection in the tonsil will often prevent subsequent attacks. Inflammation of the lining membrane of the heart is a frequent complication of rheumatism and many cases of chronic heart disease are thus set up. Another disease closely associated with rheumatism and its germ is St. Vitus dance, or chorea. Inflammation of the thyroid gland is another. Certain inflammations of the eye and skin are to be placed in the same category.

Appendicitis, ulcer of the stomach, inflammations of the gall bladder, liver, intestines, pancreas, bones, bone membranes, brain, spinal cord, peripheral nerves, kidneys, joints, and a number of other diseases and diseased conditions have come to be regarded in recent years as often produced by a focus or by foci of infection, situated in some organ or part, perhaps far removed from the seat of the manifest disease. A focus of infection in the throat, gall bladder or bronchial glands constantly or intermittently pouring out small quantities of poisonous germs may therefore supply the infectious organisms to a susceptible or injured organ or tissue and thereby bring about any disease mentioned above. It would carry us too far afield to take up each one of these diseases or diseased conditions and attempt to show what has actually been learned in each case as to their relation to foci of infection. In reference to chronic joint diseases which are quite common, and are so frequently dis-



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abling, it is believed by many competent authorities at the present time that all cases of chronic infectious joint diseases (arthritis), with the possible exception of a form due to injury (traumatic), are always due to focal infection; that is, are produced by germs from foci of infection somewhere in the body. It is interesting and highly important to note that certain types of kidney disease may be produced in a similar manner. The kidneys are the organs through which most of the germs which pass through the body without actual destruction must filter in the process of elimination. It is not surprising, therefore, that under certain circumstances these organs may develop chronic inflammatory or degenerative disease. It may indeed be possible that certain types of chronic Bright's disease come about in this way.

At the present day in all cases of physical debility, with or without lowering of the blood pressure, whether definite organic disease can be demonstrated or not, it is the practice of physicians to search carefully for some focus of infection. This search may involve the use of all the diagnostic skill and means which modern medicine has at its command.

A word as to treatment. The primary principle is, of course, the eradication of the focus of infection. If it lies in the tonsil, then the operation of tonsilectomy must be performed. Some judgment will be here required to prevent the indiscriminate sacrifice of organs whose function may not be entirely menacing and detrimental to the organism. If a focus of infection is around the apex of a tooth and conservative measures are insufficient, then the tooth must be sacrificed. A few

years ago when infected teeth were first incriminated, as frequently constituting foci of infection, many unnecessary extractions were performed. Nowadays a more conservative attitude prevails. Nevertheless the teeth should be subjected to a careful scrutiny in every case where the presence of focal infection is suspected.

After the removal of the focus of infection, the patient will require tonic, hygienic, and supportive measures to overcome the effects of systemic infection. The use of vaccines in these conditions has been a disappointment to most physicians and their use is being curtailed. This is not meant to say that they are contra-indicated, only that they have not yielded the results which early promises held out for them. The injection into the veins of certain forms of albuminoid or protein substances has produced rather remarkable results in the treatment of these conditions very recently, but such severe reactions are apt to follow their use as to render them unfit for general employment. It is possible that further developments along this line will finally reveal nonpoisonous but effective substances of a protein nature which will produce definitely beneficial results in the treatment of focal infection.

CHAPTER XI

CAUSES AND FACTORS OF DISEASE OTHER THAN INFECTION AND HOW THEY ACT

HEREDITY

HEREDITY is the name given to the fact or generalization drawn from observed facts of life that animals and plants closely resemble their progenitors. It may be also more scientifically defined as the property of a fertilized egg, that is, an egg able to reproduce its kind, or of any piece of an organism that is capable of further development to reproduce the specific form to which it belongs.

Practically everyone believes in heredity and practically the only limitation to universal belief in it is in regard to its application to individual cases. If we find a special kind of deformity, such as being born with an extra finger, occur and reoccur for generations in a single family, everyone will pronounce the peculiarity to be hereditary. If only a single isolated case occurs in a family, some doubt will arise as to its being of an hereditary nature. It is usual to attribute similarities of gesture, deportment, speech, mental capacity or, on the other hand, abnormal conduct, feeble-mindedness, and epileptic fits to heredity when they affect different members of a family through succeeding generations. When isolated examples of these conditions

occur in a family there is not the same disposition to be certain that they are hereditary. Careful investigation of each instance is necessary before any degree of certainty can be reached.

Among animals and plants the new or young organism arises from portions of living matter detached from the parents, but different from the latter in structure and size. In other words, the young or progeny are made out of living bits of the parental protoplasm; protoplasm being the general scientific term denoting living matter. These little masses of parental protoplasm pass through a primary stage of development called the embryological development, during which they may or may not be attached to one of the parents. They undergo growth, multiplication into numerous, even millions of new cells, which through mysterious specializations become the organs and tissues of the new being. The actual process by which this little germ mass slowly becomes an adult individual like its parent, depends upon the interaction of two sets of factors or forces; first, the inherent mysterious properties of the germ material itself which we cannot define but know to exist, and secondly, the influence of conditions external to the germinal material.

This latter we call environment. The exact part played by each of these factors in the development of a living creature from its tiny germinal beginning to its adult state is a problem difficult to solve. All we know is that by their interaction, the being is finally formed with characters like those of his parents and characters which may appear to be different. Every character found in a parent may or may not be present in the offspring.

When any characteristic occurs in both parent and offspring, it is said to be transmitted. Such characters include form, stature, anatomical construction, physiological or functional tendencies. Not only are normal characters, but also diseases or pathological characters transmitted. Every character, therefore, which an individual possesses is the result of two sets of factors. One is an inherited set of factors which has come down directly to him in the germ plasm of his parents from which he was made, the other set of factors is that of outside influences, surroundings, education, association, which from the earliest moment of his existence tend to mold his development. These factors, innate and environmental, cannot in any individual case be given their exact reciprocal evaluation.

The popular method of expressing the relation between qualities which are wholly accidental or environmental and those which are wholly hereditary is formulated in the usual phrase "environment and heredity." It is known that a gourd seed planted in a manure pile will produce luxuriant growth, while a huckleberry seed similarly implanted will produce a sickly or inferior growth. Here the environment is the same; the end results are opposite because the innate characteristics of the two seeds are different. This example illustrates that the effect of a given peculiar environment will depend upon the hereditary nature of the stuff of which the organism is made.

Environment and heredity have, as said by Davenport, the relation to each other of action and reaction, of stimulus and response. The effect which environment has upon an organism therefore

depends at least as much upon the nature of the organism as upon the surrounding peculiarities. It is difficult to say in a given case, particularly the case of a human being, whether heredity or environment has played the greater part. The modern tendency appears to be to regard the former as more important than the latter. This does not mean, however, that environmental circumstances do not exert a powerful effect, for the contrary is believed to be the case.

It has been much debated whether or not characters acquired by the parent can be transmitted by heredity to the offspring. To consider this question fully and to attempt to discuss the philosophical and empirical considerations which have been arrayed for and against it would take us too far afield. The modern tendency is to doubt the inheritance of acquired characteristics. To illustrate, although the Jews have practiced circumcision for thousands of years, their males are always born in such a state as to require an artificial repetition of the operation. Neither, and for a like reason, can we discuss the interesting and startling conception of Nussbaum and Weismann that the germ plasm itself is immortal; that is, continuously passed on generation to generation from parent to offspring.

Inheritance is theoretically possible from each parent and from the ancestors of each. It is customary to speak of inheritance as "blended" when the offspring appears in respect of any character to be intermediate between the parents; as "prepotent" when one parent is supposed more effective in stamping the offspring than the other (for example, Jews, Negroes, and Chinese are prepotent in crosses); finally as "exclusive" inheritance when

the character of the offspring is definitely that of one of the parents.

In the crossing of artificial varieties it has been found that inheritance of characters tends to alternate. This was found by Gregor Mendel years ago and recent experiments of De Vries have corroborated him. On the other hand, in the case of natural varieties of plants and animals, "blended" inheritance predominates. The influence of ancestral attributes upon inheritance has been expressed arithmetically by Galton, who stated from statistical data that each parent contributes one-fourth, each grandparent one-tenth, and each ancestor a proportionately diminishing amount to the hereditary characters of an individual. This is only seen to be true of course when large numbers, not individuals, are concerned.

The work of Mendel above mentioned was most important to a clear understanding of the meaning of heredity. Gregor Mendel, peasant boy, monk and abbot of Brünn, interested himself in the working of heredity and carried out experiments on peas in his cloister garden, which later made a great impression upon the scientific world. Born in 1822, he published an account of his experiments in 1865, but it was not until 1900, eighteen years after his death, that his work was discovered and appreciated. Mendel found that on crossing a tall with a dwarf pea the hybrids of the first generation, usually spoken of as F_1 generation, were all tall; that no intermediates appeared. Accordingly he called the tall character a dominant, and the dwarf a recessive. On allowing these hybrids to fertilize themselves in the ordinary way, he obtained a further generation which, on the average, was

composed of three talls and one dwarf. Subsequent experiments showed that the dwarfs always bred true, as also did one out of every three tall; the two remaining talls behaving as the original hybrid and giving three talls to one dwarf. Having regard to the characters tallness and dwarfness, he found that only three kinds of peas exist, viz., dwarfs which breed true, talls which breed true, and talls which give a mixed proportion of talls and dwarfs. Since Mendel's time, many similar experiments have been carried out on plants and animals and practically similar results have been obtained. To go completely into an explanation of what these facts mean in relation to the supposed constitution of the reproduction cells would carry us into matters of speculation and description hardly eligible for elaboration here. Nevertheless, in order that the problem of heredity in its relation to disease may be better comprehended, it will be necessary to consider the mechanism a little further. It will then be pertinent to discuss the inheritance of special traits, particularly diseases and defects, and to discuss the rôle which heredity plays in the production of some special diseases.

The thing which passes from the parent to the child is a pair of germ cells. The fertilized egg only one twenty-fifth of an inch in diameter contains the potentialities of the man or woman who may develop out of it. Now the fertilized egg is known to have a complicated organization and it will be impossible to describe in this place even that which is known about its actual structures. What may properly be stated in this connection is that a certain colored material called the chromosomes constitutes the physical basis of heredity trans-

mission. In the fertilized egg, half the chromosomes come from the mother and half from the father. The details of the adult structures are determined by these chromosomes. Man as we know him is the visible expression of the substance in the chromosomes.

If two persons having precisely the same germ plasm should marry, their offspring would be exactly alike and like their parents. But in life this is never realized, for the chromosomes or germ plasm which we call human exist in hundreds of different forms, so intermingled that no two are exactly alike. Consequently, nearly all human beings are hybrid matings. If one parent, for example, belongs to a race whose external characters are very different from those of the other parent, the offspring will be like the parent who happens to have dominant or positive determiners, as they are called, in the germ plasm. To give a specific instance, if the father is short and swarthy and the mother tall and blond, the offspring will be like the father because these characters are found to be dominant. Now if two such hybrid children grow up and marry, their offspring will be varied. Some will have brown eyes, some blue, some swarthy skin and some blond, some tall, others short, because of dissimilarities of the germ plasm brought about by the hybrid mating.

The first law of heredity then is that characters due to positive determiners in the germ plasm, such as the presence of dark pigments in the skin, etc. denote, are dominant over characters due to the absence of such determiners. In general, where a character is due to the absence of determiners that cause the opposite, then if both parents lack the

character it will be absent from the germ plasm of both and all their children will be born without the character. The offspring of pure blue-eyed parents will all have blue eyes and the offspring of two feeble-minded parents will be feeble-minded.

There is also a group of characters or traits that depend upon the determiners found in the germ material of one sex only. In man the sex determiners lie in the woman germ plasm. Without attempting to explain the reason on account of its complexity, it may be stated that the mother may transmit certain traits which her father showed, whereas the father cannot transmit such traits as his father showed. Among traits whose determiners are located in the sex chromosomes and therefore only transmitted by the mother are color-blindness, bleeding sickness or hemophilia and some degenerations of the eye nerves. In typical cases of bleeders' disease the males are alone affected and in such cases it is usually the mother's father or brothers, rather than the other ancestors, who show the same trait.

In a certain number of diseases the rôle of heredity seems preponderant. The individual is born with a *tare* which leads inevitably to their development. Such diseases have been called hereditary family diseases. We cannot enumerate them here. The nervous system is especially liable; example: the so-called ataxia of Friedreich, which occurs often in several members of one family. Other examples could be given of diseases of the special senses, muscles, circulatory system, etc., which belong to the same category.

Inherent characters have their influence as a matter of fact upon every disease. Even infectious

diseases which upon first analysis are attributed to germs are influenced in their manifestations in different individuals by the inherited characteristics of these persons.

All individuals react to a certain extent dissimilarly to the same infection. In some cases this may be due to differences in the germ plasm, but in most cases it is due to differences in individual characteristics which have been inherited.

Certain diseases like tuberculosis were once thought to be inherited, but we know now that the only thing which is inherited is not the disease, but a certain predisposition to its development under favoring circumstances.

EUGENICS

Recent times have seen the development of a science of applied heredity to which the name eugenics has been given. The aim of eugenics is to improve the race by directing and controlling the reproduction of human beings. In other words, to take advantage of the laws of heredity to secure a higher and better type of inheritance.

Eugenists claim that the health and happiness of a nation depend so much upon the predominance of the physically, mentally and emotionally fit stock that it is a duty of the state to take steps to prevent the procreation of anything but that stock. Theoretically the idea is a fine one, but the practical difficulties which stand in the way of its application to society are such as to render it in the final analysis a sort of Utopian dream.

Already it is true that certain states and countries have taken measures to prevent the multiplication of feeble-minded, epileptic, and insane

individuals, but the number of these individuals is so small compared with the whole social mass that their elimination is not a matter of much consequence. The social organism tends spontaneously to destroy its degenerated portions by reduction of their fecundity and by other means. When the principles of eugenics are attempted to be applied to any but the most glaring deviations from the normal, the impossibility of providing an adequate censorship over the physical, mental and moral attributes of individuals becomes evident. Nevertheless, principles of heredity should be disseminated as far as they are known among society so that a voluntary compliance with their rules will be gradually cultivated.

Physicians especially are often confronted by serious problems which only a knowledge of the laws and phenomena of heredity will enable them to solve, and it is consequently their duty to avail themselves of all the knowledge to be acquired upon the subject.

AGE

Anatomical structure varies with age, and physiological (i. e., functional) processes have peculiarities which are characteristic of different periods of life. The effects of environment, occupation, habits of life and the wearing out of the body vary with age. Consequently, certain diseases are more frequent at certain periods of life. The diseases of youth are often the precursors of those of older years.

The period of adolescence following puberty is marked by the development of certain mental troubles, or so-called psychoses, particularly mania and melancholia. They often have an hereditary

basis. A common mental condition of adolescence is early dementia or dementia precox, which is accompanied by a gradual but premature decay of the mental faculties. It is sometimes difficult to differentiate this state from an exaggerated state of instability also common in adolescence. Changes in composition of the blood often take place during adolescence, especially the anemias, which are marked by pallor and languor.

Sex, nationality and race all have their influence in the production of disease, but any discussion of these factors would not be of sufficient general interest to justify their consideration here.

ENVIRONMENT

Environment is an important factor in the production of disease. We do not often stop to think of the great influence exerted in this regard by clothing, the home, atmospheric temperatures and food. Still less do we consider the many factors which act upon the mind, constituting our psychic environment, upon which the mental health of the individual depends to such a large extent. It is commonly believed that the atmosphere affects the body only through the absorption of its elements by the lungs, and the symptoms which accompany a sojourn in a poorly ventilated room, such as drowsiness, headache, loss of appetite, nausea, arise from the absorption into the lungs of poisons given off from the lungs and bodies of people. This is not the case. The deleterious effects are caused by the effect of the atmosphere upon the surface of the body, in the direction of preventing or lessening the loss of heat. Heat, humidity and stillness have been found to be injurious factors in a bad atmosphere,

while coolness, dryness and motion are the beneficial factors brought about by ventilation. The bad smells which assail the nose in a crowded room are disagreeable enough, but they are not poisonous; neither is the carbon dioxide exhaled by many lungs to be feared provided enough oxygen can be obtained. Absolute lack of oxygen, of course, will be fatal, and this is what killed the poor unfortunates in the famous Black Hole of Calcutta.

It has been lately urged that variation in temperature is the most important element in climate, and that no other factors going to make up the weather have the same effect. The superiority in vigor of people who live in hard rugged climates with much storminess and temperature variations is acknowledged. This is explained on the ground that persons living under this kind of environment develop the most effective circulatory mechanisms. The efficiency of the blood vessels and the nerves which control them becomes so developed under the stress of such variations that a prompt supply of blood is sent immediately when needed to any part of the body. There is not enough blood in the body to keep all the organs simultaneously working at maximum intensity, so that varying quantities of blood must be shunted into different portions of the body whenever their functional activities require to be raised. It is like the situation of a railroad whose rolling stock can never be adequate to supply all portions of the territory covered at once. Efficiency depends upon the ability of the system to distribute cars at shortest notice where they will be most required. Efficiency in the body depends upon the capacity of the so-called vasomotor or blood vessel moving

mechanism to respond instantly to each of the varying calls for blood, and furthermore to see that when the duty for which the extra blood was needed is accomplished the excess shall be called away. Within reasonable limits the oftener a function is employed the greater its efficiency, so that the environment of rugged climate with its ever-recurring temperature variations has the effect of stimulating the vasomotor mechanism to its highest point of efficiency.

The mechanism of "catching a cold" will illustrate this point. Exposure to cold and wet both have a powerful effect upon the circulation. The blood vessels on the surface of the body (skin) are constricted and quantities of blood are driven to internal organs, producing what are called congestions in different parts. Among these parts is the nose. Now if this congestion lasts longer than a very brief period the germs begin to grow and a cold is established. If the person exposed has highly efficient vasomotor mechanism the congestion will be temporary, the distribution of blood upset by the exposure will be reestablished normally and no cold develops. A lumberman can stand work with his boots full of water all day, the sailor can work in clothing soaking wet without catching cold. The city dweller must be careful to wear rubbers and avoid wet feet continually or suffer from exposure. The same city man, if he should change his occupation, leave his office and become a lumberman or fisherman, would lose his susceptibility to cold. In this instance the effect of environment has been nullified, at least in the particular of catching cold, by increased efficiency through training of the vasomotor mechanism.

Another example of the same type and one nearer the view is the general difference in the susceptibility to variations of temperature between men and women. Men wear many clothes and have more colds than women who wear fewer clothes. These facts and others of a similar kind have made popular the so-called hardening processes which are practiced with so much assiduity by some and totally neglected by others. Among these hardening processes are going without hats, wearing thin underclothes, cold baths, sleeping out of doors, etc. There is no doubt that a judicious application of these special means for training the vasomotor mechanism are beneficial in many cases. They enable the body to become less susceptible to changes in environment, by making the changes more frequent than they would ordinarily occur in nature and thus increase the bodily resistance by training its own inherent powers of defense to greater and more efficient activity.

The value of sunshine in the environment, in the prevention of disease and the dangers which accrue from living under conditions where its beneficent effects are eliminated is well illustrated by the disease tuberculosis. The germs of this disease abhor the sun's rays, as well they may, since they always succumb to their effects and the unfortunate individual who is tubercular often recovers by living in the open air and sunshine. Beneficent as the sun's rays are they are not the only factor in the cure, for the hardening process brought about by the exposure of the skin to varying temperature plays an important part. Formerly it was assumed that the efficacy of outdoor treatment in consumption and other diseases depended on the breathing

of a special kind of air. It seems more probable that the good effects depend upon the effect of high dry air upon the surface of the skin, producing more rapid elimination of heat, stimulating the vasomotor mechanism, in other words, effecting this hardening process. It is said that patients undergoing treatment obtain more benefit in winter than in summer. As has been well said by James: "If a person wants to benefit by a certain type of air, not only must he secure its entrance into his lungs, but also have its effect upon his body generally, and such effect as is produced upon the lungs is probably through the action of these inner surfaces as body surfaces and not as organs of absorption."

In respect to the effects of atmospheric environment in heart and kidney diseases, a warm and somewhat moist situation at or near sea level with moisture and warmth is best, apparently the opposite of consumption, because in these diseases the hardening process is of no particular advantage and there is more to be gained by lowering than by stimulating the chemical processes of the body. Perhaps also because elimination through the skin and sluggish circulation are advantageous.

In respect to environment in its relation to health and disease, even the position of the body has its importance. A man will die if hung with his head down. An opossum or a monkey or a bat can assume this position with impunity. Even a man can train himself gradually to do it, as witness the trapeze actor. Some wonderful physiological adjustments not entirely understood come into play. The occasional moving of the body from position to position acts for health. The prolonged assumption

of a position, even the horizontal, is deleterious. Certain kinds of changes of position in space by which the entire body is translated as upon a rolling ship produce the distressing phenomena of seasickness. James states that the phenomena of the oncoming of seasickness are the same as those of the oncoming of death, and suggests that both are accompanied by an accumulation of blood in the large veins of the body (trunk) with a corresponding lessening of the amount of blood in the arteries. In the training of aviators a machine is often used in which the embryo bird man may be placed in any posture. This is done both to test his capacity of quick adjustment to changes in position of the body and also to train these faculties to higher efficiency before he is allowed to fly.

When we take up the effects of environment upon the mind we enter a complicated field. But nowhere in medical practice is it more necessary to study the effects of environment upon human beings, for health and happiness depend so much upon it. While a good deal of empirical knowledge has long ago accumulated upon this subject, it is only in recent years that medical men have come to a thorough realization of its importance and the necessity of giving it the same if not greater attention and study than they are in the habit of extending upon other factors in the cause and treatment of disease.

The enormous vogue at the present day of religious healing and many other cults which have sprung up to compete with physicians in the battle against disease is sufficient testimony of the importance and necessity of this element in treatment. In the majority of these cults, so-called

science of medicine has been thrown to the dogs, as it were, or given scant attention and all faith is put in the efficacy of environment in its broader sense. The patient is told by some that there is no such thing as disease, and, believing this, in a state of ecstasy he refuses to be halted by any but the most serious blows which the genius of disease can deal him.

Intelligent people will gradually grow suspicious then disgusted with these one-sided and often superstitious and puerile views of disease. One of their good effects has been to awaken the conscience and stimulate the imaginative faculties of medical men. The result is that the factor environment in its relation to body and mind is coming to be better appreciated. Wonderful studies in psychoanalysis are uncovering the mechanisms of mental maladjustments and physicians are giving to the questions of the effects of environmental circumstances upon the mental life and functions, the serious attention, the close scrutiny and the scientific study which they deserve. In hospitals where patients are confined often for long periods of time more attention is given to environment. In some institutions the patients are moved from place to place to obviate the effects of monotony and ennui. Even a transfer from one institution to another has been attempted in some hospitals for the treatment of mental diseases.

The war produced thousands of cases of hysteria which afforded a mine of information for those to explore who were interested in the study of mental environment as a factor in the causation of disease and its amelioration. Doctors have long been accustomed to prescribe empirically a change of

environment for their patients, but it is only recently that a serious attempt has been made to scientifically study the mechanism by which the good effects upon mind and body have been produced.

As James has well said: "We cannot think of life as an isolated fact, but only as a complex, the result of a large number of coordinate facts, which should be in harmony with one another, but which unfortunately often are in disharmony. Health and disease are not isolated facts. Man and his diseases are parts of a complex in which the environment, both physical and mental, plays an important rôle."

OCCUPATION

Occupation is a species of environment, but of such extreme importance as to form a branch of study in itself. The relations of different occupations to health and longevity have received the attention of medical men from early times. Not until comparatively lately, however, has a true science of occupational and vocational hygiene been developed. Hippocrates and Galen knew that certain occupations and trades, even in that primitive period, were dangerous to health.

The factory system originated in the beginning of the sixteenth century, while the modern factory system started in the latter part of the eighteenth century with the introduction of the spinning machine, the power loom and the steam engine. Children began to be employed in the factories and this introduced a social factor into hygiene and medicine which has occupied the attention of students ever since, and it is only in our day that satisfactory solutions of this problem of child labor have been made.

After the advent of the modern factory system, occupational diseases and accidents assumed great importance and this led social economists and physicians to take a large interest in the question, with the result that at the present day an awakened conscience guided by wise legislation is operating to prevent or to mitigate the injurious effects of occupational environment. Among the evidences of this improvement is the existence of workmen's compensation acts, industrial insurance and a host of hygienic betterments of living conditions among factory employees.

In our own country the U. S. Department of Labor and the departments of labor of the several States have carried out scientific investigations in almost every branch of work. Many types of safety devices, dust eliminators, etc., have been perfected and introduced, and every conceivable branch of industrial hygiene has been cultivated. It will be impossible to go far into the subject of occupational disease. It may be stated, to give a more adequate notion of the wide scope of the matter, that various substances used in the arts are particularly poisonous, which fact gives to the subject of occupational intoxications great interest.

In the group of occupational intoxications are included poisoning by arsenic, carbon monoxide, lead, benzol, mercury, phosphorus, etc.

The study of the effect of dust in the production of diseases of the lungs, of fatigue in the production of nervous conditions and of the particular dangers attached to many trades, such as the making of glass, jewelry, steel, fabrics, etc., constitute important branches of occupational hygiene which for lack of space cannot be dwelt upon.

Every new occupation brings its new diseases and its dangers for medical men to study. Aviation, the newest occupation of the world, has brought its great problems of qualifications for air service, the psychophysical examination of aviators, and greatest of all, the problem of accidents. Two thousand and thirty-four fliers and observers were turned over by our American army to the zone of advance and to allied squadrons after our entry in the World War, and prior to the Armistice 506 were killed in accidents and only 169 were killed in actual combat. The problem of eliminating accidents in aviation is receiving the skillful attention of many experts in different lines at the present day.

FATIGUE

The exercise of the bodily functions may become, when they are pushed to the point of fatigue, the point of departure of persisting disorders. Chronic congestions of organs may thus be brought about. Finally actual organic changes may be set up. Fatigue is, therefore, a condition which must be taken into account in any consideration of the causes of diseases.

Fatigue in the individual has its physical and mental aspects. After a person has been active mentally or physically for a certain length of time he feels "tired," as we say. This sensation is a warning that further effort will be harmful. The result of fatigue will usually be a diminished capacity for work.

The diminished capacity for work produced by fatigue is in reality due to certain chemical changes which take place in the overworked part. Certain chemical substances, for example, are known to

accumulate in muscles as a result of repeated contractions which are quickly removed under normal circumstances by rest. In a complex organism like the human body the excessive use of one part increases the work of others. Muscular fatigue brings on brain fatigue and vice versa. A drain upon one organ brings on a drain of others. Local fatigue results in general fatigue. A person who has worked hard enough to tire his muscles is apt to have a tired brain as well and an exhausted brain worker cannot immediately perform hard physical labor. A change of work is often suggested as beneficial and so it is temporarily, but if the individual continues to overdo at the new occupation the beneficial effects will be lost.

Strange to say, the sensation of fatigue, unless developed to an extreme degree, does not necessarily indicate a diminished capacity for work, for it has been demonstrated by laboratory tests that a given task may be performed as effectively and as readily whether the individual feels tired or not. A student, although fatigued to the extent of having an aversion for further work, will be able to solve arithmetical problems as quickly and correctly at the end of such a series of tasks as at the beginning. He will be disinclined to work, but there will be no diminution of his capacity. When fatigue is developing, a slight change in the character of the work or a change in the environment may temporarily diminish the sensation. Thus music has been found to diminish the fatigue of marching soldiers.

Rest, of course, is the cure for fatigue. It is obvious that rest brings recuperation. How it does so is not entirely known, but undoubtedly fatigue substances are thereby removed from the body, the

cells are rebuilt or repaired and potential energy accumulates.

The actual connection between fatigue and disease is a very large subject as well as a complicated one, and only a small space can be devoted to it. To disease fatigue stands in the relation of both cause and effect according to circumstances. That it may be a factor in causing disease has been amply proven. Thus it has been shown experimentally that of two groups of animals, the one fatigued, the other resting, the inoculation of disease-producing germs in both will result in a much larger percentage succumbing to the effects in the first group than in the second. This is usually interpreted by saying that the resistance of the body to the deleterious action by germs is diminished by fatigue. From the prevalence of infectious diseases in man it is obvious how important is the matter of avoiding undue fatigue. One author has put the matter epigrammatically thus: "first is fatigue, then colds, then tuberculosis, then death; prevention to be effective must begin at the beginning."

Fatigue is an important factor in the production of neurasthenia or nervous exhaustion. Here the fatigue is primarily or secondarily related to exhaustion of the nerve centers. It is not common for mere muscular fatigue unattended by any factors inducing exhaustion of the nerves, to produce neurasthenia. Overwork, overpressure and overstrain bearing upon the nervous system are the ordinary precursors of neurasthenia or nervous prostration.

Fatigue besides being the cause of disease may also figure prominently in its effects. Diminished capacity for work, sensations of exhaustion, obviously fatigue itself, are almost inevitable and uni-

versal accompaniments of diseases that involve alterations of the general chemical changes (metabolism) of the body such as infectious diseases, fevers of all kinds, diabetes, etc. In these types of diseases the breaking down of the tissues of the body are greater than their construction, expenditure of energy greater than its renewal and fatigue is a necessary and comprehensible result.

PHYSICAL AGENTS AS CAUSES OF DISEASE

Heat, Cold, Light (Radiation), Electricity, Sound, Atmospheric Pressure, Injury (Trauma).

The question of environment and its relation to disease has already been considered in its general aspect. Here we take up a few specific phases. Man like all living beings is constantly subjected to the influences of his environment. His maintenance in a state of health is only made possible by a constant struggle between the play of external forces and certain regulatory mechanisms of the body which tend to neutralize their effects.

External conditions tend constantly to modify the life conditions of our cells; the regulatory mechanisms in our bodies tend to maintain internal conditions in a state of health. These regulatory mechanisms are essentially composed of a sensory or feeling apparatus varying with the external agent whose variations are to be perceived, of nerve centers, the seat of reflexes which put in play the perceptions of the feeling apparatus and of nerves called centrifugal which set the organs in action which must be called into play. In higher animals and in man these regulatory mechanisms have reached a high degree of perfection and develop-

ment. Thus man may subject himself to or undergo with impunity great modifications in his external conditions. Nevertheless, if these changes are too great, or if the regulatory mechanisms are inadequate, the body cells will be injured and disease or even death may be the consequence. The internal environment succumbs to the external. The higher the animal is placed in the organic scale the more sensitive it is to changes in its own internal constitutional environment. Warm-blooded animals, for example, can support great variations of the external temperature and still maintain their bodies in a normal state. The normal internal temperature of human beings is 98.4 degrees Fahrenheit and this is not changed with wide variation of the external temperature, except within very narrow limits. The opposite is true of cold-blooded animals, in which the mechanism regulating internal temperature is scarcely developed and which can support great variations in the actual temperature of their bodies.

As with heat, so with light, humidity, pressure, electricity and other physical agents; all these influences and others acting upon the organism are tempered in their effects by regulatory mechanisms in the body.

Heat and Cold.—Man lives in an environment where the temperature is always lower than his own. Consequently in him, heat regulation is always more perfect toward temperatures which are lower than those which are higher than his body. Thus while man can survive temperatures 90 to 100 degrees below that of his own, he dies in a temperature that exceeds his own by 10 to 20 degrees. The temperature of the human body itself may be

lowered 20 to 30 degrees without fatal results, while death is certain if it be raised 8 or 10 degrees.

The heat regulation of the body is carried out principally by the reciprocal reflex play of centers presiding over the blood vessels and secretory glands. If the temperature rises, the heart beats more rapidly, the skin capillaries dilate and heat is radiated from the skin. Sweat is abundantly secreted and through its evaporation heat is lost. Breathing is hurried and heat is lost from the lungs. When the temperature is lowered an opposite set of conditions prevail.

The rôle of evaporation explains why high temperatures are better supported in a dry air than in a moist. While temperatures of 200 degrees Fahrenheit and over can be supported for ten minutes in dry air, it is impossible to support vapor baths above 80 degrees. Hot climates such as found in the region of the equator are generally insalubrious, especially to persons who are unaccustomed to live under such conditions. Not only individuals succumb, but their families become extinct after long tropical residence. The unhealthfulness of hot countries depends to a certain extent upon the extreme prevalence and virulence of certain infectious diseases, particularly malaria and dysentery. Digestive disorders are especially common in the tropics. Finally certain diseases are found only in these regions, for example, sleeping sickness or trypanosomiasis.

Heat Stroke and Sun Stroke.—By heat stroke is understood a group of symptoms produced in individuals who are subjected to the action of high temperatures either in the open air during the summer or in torrid climates or in a hot confined space.

It is often observed in stokers employed in the boiler rooms of ships. The action of the heat coagulates the albuminlike substance of the muscles. The rigor mortis or stiffness of death comes on immediately. Death is produced by stiffness or rigidity of the heart muscle and the diaphragm or breathing muscle between the chest and abdomen. The heat produces an increase in the oxidation of the muscles, and this sets free acid bodies which coagulate the muscle tissue. The direct action of the sun's rays upon the head may give rise to congestion and inflammation of the brain and its membranes and this is called sunstroke or insolation.

When any of the tissues of the body are subjected to extremely high temperatures the result is a burn. The tissues affected will be inflamed, blistered or destroyed, according to circumstances.

Cold is the absence of heat and its actions can be produced under a variety of conditions. Intense atmospheric cold may bring about death as occurred to Scott and his companions in the quest for the south pole. When the effects of intense cold are exerted upon a limited area of the body the result is freezing or frostbite, which may lead to congestion and gangrene with destruction of the part.

By "chilling" is meant the impression which the human body undergoes when the surrounding temperature is suddenly lowered. Chilling is a relative term, as it may occur in hot climates as well as cold and in summer as well as in winter. Following a chilling of the surface of the body the individual is apt to "catch cold" as it is called. The common circumstances which induce chilling and which are followed by catching cold are sudden changes of atmospheric temperature, exposure to rain, wind, or

air currents, going from a warm room to a cold one or vice versa, cold baths taken when the body is overheated, cold baths not followed by exercise, insufficient or superabundant clothing, etc. In susceptible persons these experiences are apt to be followed by a "cold." "Catching cold" may display itself by symptoms of congestion of the mucous membranes of the air passages with head cold, bronchitis or catarrhal pneumonia; by congestion of the digestive organs with sore throat, stomach catarrh or diarrhea; by congestion of the mucous membrane of the eye with a catarrhal inflammation; by congestion of the serous membranes surrounding the joints, heart, lungs; by congestion of certain internal organs or tissues, especially the kidneys and sheaths of the nerves. Almost all if not all of these conditions are supposed to be produced in the final analysis by the growth of germs, the "cold" acting by diminishing the bodily resistances.

Light, Electricity and X-Ray Radiation.—All living organisms including man are subject in different degrees to the effects of light radiations. Plants absorb less carbonic acid and animals give off more carbonic acid in light than in darkness. The development of the larvæ of insects is accelerated by light and retarded by obscurity. Ducks while being fattened are confined in darkened shelters, because their combustions are less active. In man, light exercises an equally stimulating effect upon nutrition. In children, the body temperature is lowered by being kept in darkened rooms.

Absence of light is one of the factors which render long sojourn in such an environment unhealthy. Miners, workers in caves, cellars and darkened rooms become anemic and easily tubercular. The

sun's rays, when they strike the unbroken skin, will quickly produce a burn, as all can testify from their experience at the seashore. The eruptions of smallpox and pellagra are especially evident upon the uncovered surfaces of the body.

The amount of light admitted to the interior of the eye is carefully guarded by the iris, which quickly contracts the pupillary opening proportionately to the amount of light. Powerful lights may even diminish the sight.

It will be impossible to deal at length with the effects of electricity. Of course it is well known that electricity may kill. Lightning is said to cause the death of five thousand people per year.

Since electric currents of high voltage have come into extensive use in industry and in railway traction numerous severe and even fatal accidents are being continually recorded. Shocks of one thousand to two thousand volts are often deadly. Death is brought about by arrest of the heart action and by paralysis of the nervous system. Locally, electric discharges of high tension produce burns and even gangrene.

The Röntgen rays or X-rays are a particular kind of radiation produced by passing an electric spark through a vacuum. They possess the power of passing with ease through many substances ordinarily opaque to white light. The discovery of the Röntgen rays marks an epoch in modern medicine. The X-rays when allowed to strike the skin in high concentration produce burns which are slow to develop, but which are equally slow to heal. Before these effects were understood many serious results were produced. Röntgenologists at the present time know how to prevent these bad effects.

Mechanical Causes.—Little need be said concerning the mechanical causes of disease, since this topic more properly belongs to surgery, a subject which, owing to its vastness and complexity, could not be considered in a volume of this size. Under mechanical causes would naturally come all possible types of injury (trauma) including contusions, bruises, fractures of bones, dislocations of joints and all types of wounds.

CHEMICAL AGENTS, CAUSTICS, POISONS

The part that poisons of all sorts play in the production of disease is well known to everyone and easily understood. Many chemical agents have a violent corrosive effect upon the tissues when they come in contact with them, and death is often produced accidentally or otherwise in this way. Naturally, no attempt will be made here to describe the nature and effect of poisons, as their number is legion. It is believed that the body itself under abnormal circumstances elaborates substances which are poisonous to the organism unless quickly eliminated. Such condition is called an autointoxication.

DISEASES DUE TO DEFICIENT DIETS—THE VITAMINES

The actual amount of food taken into the body is so guided by the appetite and other bodily sensations that it approximately covers what the body needs. Under normal conditions, if there is any disparity between intake and body needs it is on the side of luxury, not otherwise. The intake of proteins (albumins) is usually in excess of the bodily needs as judged by experiments, but the excess is promptly attended to chemically and eliminated. Slight excess of protein is actually an element of

safety in the diet, for if the amount and character of protein food be insufficient, disturbances of growth and health result. Not only protein, but a variety of other food substances as fats and sugars are habitually taken in the food in excess of the minimum body requirements. This excess may cause a limited storage in the body, but beyond this limited storage the excess is gotten rid of. If, however, for any reason the intake of these substances falls below the required minimum, disturbances of nutrition will occur.

Such nutritive disturbances may not appear immediately, for a certain amount of the substance that is cut out of the food may be present in the tissues and the body will immediately economize such stores until a further supply is received. Even the mineral salts in food are essential to health, although they do not supply energy to the body. They are essential, however, in keeping the solutions in and about the cells in a fixed degree of concentration. Common salt or sodium chloride is usually taken by man in considerable quantities, two and a half teaspoonfuls (10 gms.) being the usual daily portion. This amount is greater than what is absolutely required, but is entirely harmless under normal conditions. In certain diseases of the kidneys it has to be reduced. Lime salts, phosphorus compounds and iron are also essential. Even though mixtures of pure fats, starch-sugar (carbohydrates), proteins, and salts are fed to growing animals in quantities sufficient to supply their calculated ordinary requirements, they will not flourish and will eventually show disturbances in growth and nutrition. Other factors are necessary. These are the vitamins.

The story of the vitamins deals with one of the most interesting chapters of nutrition. Up to a few years ago it was generally conceded that the only substances in foods indispensable to nutrition were proteins, fats, carbohydrates or starch-sugars, and mineral solutions. It has only recently been discovered that besides the above indispensable constituents our foods must comprise other substances of which the characteristic is that their nutritive importance is out of all proportion to the minute quantity in which they are normally consumed. So long as people can command not only a sufficiency of food but also a variety and use these in fresh condition as nature made them, appetite and instinct may be sufficient to secure efficient nutrition. But when natural foodstuffs are treated artificially—when for instance one kind of food material is fractionated and the consumer presented with only a part (as in highly milled flour), or when a material is dried or heated for preservation or other purpose, or when foods are sealed up and kept for long periods, or frozen, it by no means follows that the food will be adequate for nutrition even if eaten in sufficient quantity to satisfy the appetite. Naturally, the curious will propound the question—why? The answer lies in the story of the vitamins.

In certain rice-eating communities of the East, as Japan, Malay Peninsula, Dutch East Indies, Philippines, a curious and serious disease called beriberi has for some time been known. This disease is characterized by the onset of wasting paralysis or general dropsy or both combined. It was for a time thought to be due to a germ or microorganism. To be sure, rice had also been blamed as the cause and

it was supposed that spoiling of the grain was the factor. Finally in 1897, Eykman, a Dutch physician in the East Indian service, instituted a careful and statistical inquiry into the diets of inmates of prisons. Rice constituted then, the principal element of the diet, as it does to-day among large classes of Oriental peoples. Formerly, the whole rice grain including its outer coats was ground into flour, but after the development and introduction of modern machinery the process of milling removed the outer coat. In the first case the rice flour had a certain color and in the latter was perfectly white. The rice grain before the removal of its outer coat was called unpolished rice and after its removal polished rice. The polished rice began to be preferred because of its white appearance.

Eykman found that in thirty-seven of the prisons investigated, unpolished rice was used and in only one was beriberi found. In thirteen prisons the rice used was a mixture of polished and unpolished grains, in six of these the disease was encountered. In fifty-one prisons where the rice eaten was exclusively the polished variety, the disease was found in three-fourths of the institutions. On the basis of individuals he found that for every ten thousand inmates in these prisons there was only one case of beriberi among those eating unpolished rice, four hundred and sixteen cases among those on a diet of mixed rice and about four thousand cases in those whose diet consisted of the polished variety. Eykman followed his statistical researches upon beriberi by experiments. He found that fowls fed exclusively upon polished rice sickened and died. These experiments were repeated by others and con-

firmed. It became evident that the cause of beri-beri lay in the removal from the diet of a substance or substances present in the outer coat of the rice seed which was removed by the process of milling or polishing. Many investigators set about to unravel the mystery; to discover the nature of the substance so vitally necessary for the maintenance of proper nutrition.

One of these investigators whose name has since been prominently identified with the question was Casimer Funk, who coined the name *vitamines* to designate those accessory substances present in food in small amounts, the chemical nature of which is unknown, but whose presence in the diet is absolutely essential for the proper maintenance of nutrition.

The effects of the deprivation of *vitamines* from the food may be easily demonstrated by animal experimentation. If, for example, rats are fed upon a mixture containing pure protein, say casein of milk, pure starch, vegetable fat and salts, although this diet theoretically contains all the substances necessary for the animals' nutrition, nevertheless they will sicken and may die. If, however, a minute amount of fresh milk, say 3 to 4 per cent of the total, be added to the diet, the animals grow normally. A minute amount of other substances besides milk, particularly fresh vegetable substances, will have the same effect. If now the fat supplied in the artificial diet be butter instead of vegetable fat, and a small quantity of the outer coats of the wheat or rice grain be incorporated with the foods, this diet will be found entirely adequate to all the needs of the animal. Without these additions this diet will be insufficient to maintain life for any considerable length of time.

The early experimental work demonstrated the existence of at least two accessory substances or vitamins in food; one associated with certain animal fats and one soluble in water. Both must be present in any diet if it is to be sufficient.

The first of these vitamins was labelled by McCollum fat soluble A, the second, water soluble B. The water soluble B vitamin is apparently identical with the substance present in rice polishings, the absence of which causes the disease beriberi above mentioned. It is the absence of this vitamin (water soluble B) which causes animals in experiments like those described above to sicken and die. Water soluble B vitamin is found in the germ layer of cereal grains and seeds, also in fresh meat, fresh and dried vegetables, fresh milk, eggs and yeast.

The deprivation of fat soluble A from the diet also leads to profound disturbances of nutrition although it was found more difficult in the case of this vitamin to discover the effects of its removal from food than was the case with water soluble B vitamin. This is due to the fact that animals normally store up a large reserve of this vitamin in their fat deposits which they seem able to use when the element is lacking in their food. Nevertheless, careful experiments have shown that very distinct symptoms follow the deprivation of fat soluble A from the diet, among which symptoms is a peculiar inflammation of the eyes. This condition appeared among children in certain countries during the recent World War on account of absence or lack of fat soluble vitamin. Fat soluble A is absent from extracted vegetable fats, since it is left behind in the plant

when the fats are removed. It is abundant in butter made from cream, but it is absent in lard and vegetable margarines.

According to Drummond, besides the above accessory substances, there is a special growth-stimulating vitamine and a special vitamine which prevents scurvy, the latter called by him water soluble C. According to Professor Hopkins of Cambridge there are numerous vitamins. It is very important for everyone to have some accurate knowledge of the distribution of vitamins in nature in order to determine whether a given diet contains a suitable variety of substances containing these indispensable elements.

The relative distribution of fat soluble A and water soluble B vitamins in certain natural products may be given in a table in which the relative quantity of either, when present, is indicated by the number of plus signs.

	Fat Soluble A	Water Soluble B
Wheat Embryo or Germ.....	++	+++
Wheat Bran.....	+	++
Wheat Endosperm (white center)	—	—
Lean Meat.....	+	+
Egg Yolk.....	+++	++
Milk.....	+	+
Butter.....	+++	—
Vegetable fats.....	—	—
Cabbage.....	++	+
Potatoes.....	+	+
Yeast.....	+	+++
Cod Liver Oil.....	++	—

The following table shows the foods which are relatively rich and relatively poor in water soluble vitamins.

Relatively Rich	Relatively Poor
Brewers' yeast	Sterilized milk
Ox heart	Sterilized meat
Milk	Cabbage
Beef and fresh meats	Turnips
Fish	Carrots
Beans	Highly milled cereals and flour
Peas	Starch
Oats	Pork
Barley	Molasses
Wheat	Corn syrup
Corn	

The following table gives the general distribution of so-called antiscurvy vitamins in foods.

Relatively Rich	Relatively Poor
Fresh vegetables	Dried vegetables
Fresh meat	Dried fruits
Fresh fruits	Sterilized milk
Raw milk	Canned meat
Raw meat	Dried cereals
Cereal sprouting	Pork fat
	Starch
	Molasses
	Corn syrup.

It may be seen from the above tables that white or highly milled flour is lacking in water soluble B vitamins. War flour on the contrary contained it. It will also be seen that fat soluble A vitamins, though present in butter fats and cod liver oil, is absent in vegetable fats and oils, and in lard. The cheaper forms of butter substitutes are often prepared from vegetable oils, consequently it has been recommended to incorporate ten per cent of real butter with them to supply the growth-producing factor. Lard will not do it. Vitamins are suscep-

tible to temperatures above 100 degrees centigrade (212 Fahrenheit) and prolonged heating at 120 centigrade (248 Fahrenheit) for one to three hours will destroy their activity. Ordinary domestic cooking does not affect water soluble B vitamins and temperatures around 100 degrees centigrade do not impair it. Nor do ordinary methods of preserving canned fruits and vegetables. Cold storage up to five months does not destroy it, while prolonged cold storage does so. In salted, tinned and dried meats this vitamin is killed. Pasteurizing milk, by which process the milk is heated to 140 degrees Fahrenheit, does not destroy it.

The antiscorbutic vitamin is more readily killed. It is destroyed by moderate heat, by alkalis, by drying and canning. It is quite impossible in our present state of knowledge to say how the vitamins act. Professor Hopkins compares the building of the body to the building of a house, in order to get some idea of how the vitamins act. The essential bricks or blocks of stone would be of no use unless a little mortar or cement is supplied. The cement in the living body is the vitamin. Mortar is required in comparatively small amount in the construction of a building, and one of the chief characteristics of vitamins is that they are required in only small quantities in comparison with the other elements of the food.

At least eight well-marked diseases have become to be regarded as due to deficiency of vitamins supply. In these conditions the supply of some necessary vitamin or perhaps several vitamins is entirely lacking or grossly deficient. All these diseases have been carefully studied in recent years and their individual recognition is not a matter of

serious difficulty. The connection between them and a deficient vitamine supply has offered in many instances an effective means for prevention and treatment. But there is another and perhaps even more important phase of the subject and that pertains to conditions of only slight deficiency and not total lack of vitamine supply. Here we have, according to many students of the question, the most prolific source of trouble connected with the problem of vitamine supply, because such conditions are necessarily more frequent than complete deprivation.

Diseases due to total or almost total lack of vitamine supply are called avitaminoses. Besides the disease beriberi, above described, we must include pellagra, scurvy and rickets, three diseases commonly observed in the United States, in the same class. Even diseases due to marked deficiency of vitamine supply only occur after a considerable period of time in which the deficiency diet is almost or entirely the exclusive source of food. For example, the disease beriberi takes two to four months to develop on the polished rice diet. The disease scurvy develops in infants and adults whose diet is deficient in antiscorvy vitamine for a period of four to six months. Rickets, a disease of infants, is characterized by alterations in the growing bones and has long been recognized as a nutritive or metabolic disorder. It is now regarded as proven that this disease is associated with a deficiency in the food of fat soluble A vitamine.

An English investigator, Mellanby, has been able to construct a diet upon which dogs will develop the symptoms of rickets and he has been equally able to prevent their development experimentally by giving suitable fats. The fats which he found efficacious

are those rich in fat soluble vitamines; vegetable fats wanting in this accessory being without effect. The same experimenter found that the rickets-producing diet also leads to grave errors in the development of teeth.

Pellagra is a disease to which great interest attaches, since thousands of cases have recently been observed in the United States, particularly in the southern part. It is characterized by a peculiar skin eruption and by digestive, nervous and mental disturbances, usually running a chronic course and often terminating in death. The generally accepted view at the present time is that pellagra is an avitaminosis that is due to the deprivation from the diet of some accessory food factor or food factors. The proof of this resides in the fact that the disease has been produced by Goldberger with experimental diets deficient in vitamins and cured by the same investigator with diets to which vitamins are abundantly supplied.

Scurvy, a disease characterized by great debility, anemia, spongy condition of the gums and tendency to bleeding, has been known from early times. It occurred among the crusaders of Louis IX, and has prevailed among armies in the field and among sailors on long voyages. During the Civil War in this country it was well known. During the great World War it was seen in abundance. It appeared in Mesopotamia among Indian troops who did not eat the horseflesh ration accepted by the British soldiers. It appeared in Glasgow and middle England counties in 1916-17 when there was a scarcity of potatoes. Infantile scurvy is found among the poorer children of urban populations, usually from October to May. It is now generally

believed that scurvy is due to the absence from the diet of an essential accessory factor in the food, hence an avitaminosis. The necessary factor has received the name antiscurvy or antiscorbutic vitamine. It is widely distributed, according to Chick and Hume, among all animal and plant tissues. Dried vegetables lose this vitamine, but regain it when sprouting. Cow's milk is poor in it. Fresh meat contains large amounts. Potatoes are, however, the principal article of food which keeps the people of the western world supplied with antiscurvy vitamine. When the potato crop fails in Scotland and Ireland they have scurvy. It has developed from the same cause in the United States. All root crops, onions, carrots, beets, and turnips are rich in antiscurvy vitamine.

Domestic cooking does not injure the antiscurvy vitamine; it passes over in the juices. Slow drying at 37 degrees centigrade will destroy it. Carrots heated to 130 degrees Fahrenheit lose this factor. Pasteurized, dessicated (dried) and condensed milk are lacking in this vitamine and are the source of most infantile scurvy. Fruit preparations put up by modern factories are not rich in antiscorbutic vitamine. Preservatives have a bad effect upon it.

According to Chick the ideal antiscorbutic is the onion. Bran, the germ of seeds and brewer's yeast, so effective in beriberi, are of no service in scurvy. Fresh fruits and fresh vegetables are effective antiscorbutics, but prunes are ineffective and bananas are poor in power. Oranges are good and even orange peel is effective.

It is to be remembered and particularly emphasized that the absence of diseases like beriberi, pellagra, rickets, scurvy, etc., from a population, is not

conclusive evidence that deficiency in vitamine supply does not exist. There are numerous nutritional and metabolic disturbances of varying grades of severity which may very properly be attributed to a diminution in supply of accessory food substances, although the deficiency is not great enough to bring about the more serious diseases which are known to be due to a total or almost total absence of them.

From the settlement of our country in the early seventeenth century up to the last quarter of the nineteenth century bread was made from whole wheat or corn flour. At this latter period came the introduction of the steam roller mill with its pure white flour devoid of the aleurone layers of the seed, hence stripped bare of vitamines.

The dietary deficiency of wheat and corn flour and of highly milled flours from other cereals, which form so large a proportion of the food of this country is becoming more and more generally appreciated. The same indispensable accessory factor of vitamine is removed from wheat and corn by modern milling as is removed from rice by the process of polishing, namely, water soluble B. The small amount of fat soluble A which is present in the covering of these seeds is likewise removed. The danger will be in proportion to the extent to which these flours are consumed in the diet. Hopkins insists that brown bread and butter from the standpoint of vitamine supply is an excellent combination. Again, should vegetable margarines come to displace entirely the butter made from milk, a deficiency of fat soluble vitamine will result.

Finally, should canned or tinned foods come to be substituted for fresh vegetables, fruits and

salads, the diet will become deficient in antiscorvy vitamine.

The high cost of living has an important bearing on the question of food deficiency disorders. Foods deficient in vitamins are usually the cheapest foods. Rising cost makes the diet less and less rich in vitamins. Pellagra is an instance of this in this country. In southern districts where, owing to economic conditions, the diet of certain classes consisted principally of milled corn and fatback, pellagra was widespread in such communities.

A supply of fresh fruits, bananas, oranges, apples and plenty of potatoes, carrots and turnips must be kept cheap enough for everyone to buy. Butter substitutes should contain ten per cent of butter fat. Bread made from less highly milled flours should be abundant. Any tendency to increase carbohydrates (starches) at the expense of fats and proteins should be checked and we should urge the use of vitamine-containing foods.

THE CHEMICAL CHANGES OF THE BODY (METABOLISM) AND THEIR RELATION TO DISEASE

The chemical transformations within the body taken in their entirety constitute its metabolism. The products which result from the digestion of food are absorbed from the intestinal tract. Some of these products are almost immediately broken down into simple compounds, some are stored up in the body for future use and others serve to build up the tissues of the body and are finally broken down into waste material which escapes from the body. The body may be likened to a living stove in which the various elements of the food are burned like coal, giving off energy by

which work is accomplished. Just as the combustion in a stove gives off energy in the form of heat, so the human stove gives off heat through conduction, radiation, and evaporation. The amount of heat actually given off by the body can be accurately measured by a delicate instrument called a calorimeter, and thus the amount of energy transformation can be directly measured.

The energy liberated in the body may be indirectly calculated if the amount of food substances burned are known. For it is known just how much heat is liberated when a given amount of the different basic substances of food are burned. These basic substances are fats, albumins, or proteins, carbohydrates and sugar. The unit of heat in these estimations is called the *calory*, which is that amount of heat required to raise fifteen drops of water one degree C. Now the different foodstuffs mentioned above when burned produce different amounts, that is, a different number of calories of heat. Meat and bread have a certain value in this regard which is about equal, while butter has a value over twice as great. This is expressed in terms of calories produced by burning or oxidizing fifteen grains or a gram of the different substances; thus:

One gram of protein or albumin (meat) yields when burned
4.1 calories

One gram of starch or sugar yields when burned 4.1 calories

One gram of fat, as butter, for example, yields when burned
9.3 calories

In studying the chemical changes of the body, its metabolism, by the indirect method of calculation above mentioned, it becomes necessary, of course, to find out the amount of material burned up in the body and also the kind of material burned, that is,

fat, albumin, or sugar. This is done by studying the waste products thrown off by the body, for by this means it is possible to calculate the amounts of raw materials from which the wastes are derived. The urine contains a notable amount of waste material, especially that which comes from the albumin (protein) class, or as it is called by the chemists, the nitrogenous waste, because nitrogen is the characteristic element of protein substance and is not found in fats, starches, or sugars. The nitrogen waste in the urine therefore furnishes an index of the rate of protein chemical change (metabolism). The next step is to determine the amount of oxygen absorbed and carbon dioxide eliminated by the lungs for this gives a measure of the amounts of fat, sugar, and starches burned up in the body, for these substances are eventually oxidized to carbon dioxide and water, the former of which leaves the body in the expired air.

It is possible to determine the separate amount of fats and sugars burned by determining how much oxygen is absorbed and how much carbon dioxide given off. The ratio between these constitutes a quotient called the respiratory quotient, which equals one in the case of sugar, but is less than one in the case of fats and varies in a known manner with mixtures of these foods. The rate at which heat is formed in the body by combustion varies, but is influenced particularly by exercise and by eating. Muscular exercise accelerates the chemical change of the body more than any other factor. Even sitting and standing make a great difference in the ratio of heat production. Violent exercise may under exceptional circumstances increase the rate to nearly ten times its normal.

The chemical changes in the body are very much less during sleep than during the waking state and are higher in the afternoon than in the morning. Exposure to cold with consequent shivering greatly increases the rate. It is a matter of common knowledge that when a person eats a hearty meal, especially in warm weather, he feels warmer and may perspire and that during cold weather a good dinner increases the resistance to cold or exposure. The explanation for these facts is that there is an increase of chemical combustion in the body with greater liberation of heat after the ingestion of food. The amount of heat set free differs with different foods, for the meatlike foods are more effective in this regard than either fats or starches (carbohydrates). The cause of this increased metabolism after food is a direct stimulating effect of the digested substances upon the cells, the substances derived from meatlike food being more stimulating than those derived from the other varieties.

The metabolism which goes on in the body when the individual is at perfect rest and has fasted for fourteen to eighteen hours is called the basal metabolism. The basal metabolism increases with the weight, consequently the rate of metabolism per unit of body weight is used as a basis for comparison. The average basal metabolism of a normal adult expressed in the amount of heat given off is twenty-five calories for every kilogram of body weight per day. Lighter individuals have greater basal metabolism than heavier ones; tall individuals than shorter; men than women; and children than adults. Comparison of basal metabolism is also made on the basis of heat production per unit of body surface, but the actual body surface is hard

to estimate. Finally the metabolism of a person with a given disease, say goiter, is best understood by comparing it with those of a group of normal persons of the same age, height, and weight. The basal metabolism above described is distinctly increased in amount in certain diseased conditions. In the disease known as prominent eyes goiter (exophthalmic goiter), a condition in which the thyroid gland of the neck enlarges and the eyes become popped or prominent, the basal metabolism may be increased fifty to ninety per cent. In a curious blood disease known as leukæmia, or white-blood, in which the white blood cells become enormously increased, the metabolism may be raised twenty-five to one hundred per cent. The basal metabolism is markedly reduced in conditions of lowered activity of the thyroid gland, as cretinism and a curious condition occasionally found in adults called myxedema, where a mucuslike substance accumulates in and thickens the skin. In such conditions the basal metabolism may be lowered forty-five to sixty per cent of the normal. When extract of the thyroid gland is given by mouth to these patients, the basal metabolism becomes normal.

Obesity.—Whenever the amount of food material assimilated in the body is greater than the amount consumed therein by metabolic processes a deposit of energy-containing food material takes place. The ability of the body to store up the products of meat foods (proteins) and starch-sugar (carbohydrate) is limited, consequently any considerable excess of food leads to an accumulation of fat. This condition is known as obesity. Obesity is always due to the fact that the food energy absorbed is greater than the food energy

expended. It is common knowledge that overeating and lack of exercise tend toward obesity. It is also commonly known that some persons grow fat who eat in moderation and take a normal amount of exercise, while others may apparently stuff themselves and lie around inactive, but nevertheless do not accumulate fat. How can these facts be explained?

In the first place it must be considered that some fat persons who apparently eat little, really eat more than would appear on superficial observation. The value of food as a carrier of energy, hence as a fat producer, does not depend entirely upon the amount or bulk, but upon its composition. When a given amount of fat, say butter, is burned up in the body, it produces over twice as much energy or heat as the same amount of meat or sugar. The woody fibers and waste in the food supply no energy at all. A person who grows fat notwithstanding an apparently small intake of food may be selecting as foods only those which carry a large amount of energy and rejecting opposite kinds. Such a person will prefer sweets, pastries, bread and butter, to salads, fruits, and green vegetables. On the contrary a large eater of the latter types of food may appear to consume much food, but its energy value is low and he does not fatten.

In respect to energy consumed in exercise it is not always easy to compare different individuals, for certain persons appear to be able to accomplish a given task with much less exertion than others. Then, too, a nervous and restless person is constantly making useless motions and holding his muscles tense, thus using up energy, whereas a phlegmatic individual makes no extra motions,

relaxes at frequent intervals, rests and sleeps and thereby saves energy.

But even when all the above factors are taken into consideration, namely, the food intake is not excessive nor the muscular activities deficient, there are certain persons, rare, to be sure, who appear to grow fat notwithstanding. Such a tendency is spoken of as constitutional obesity, and its fundamental causes are not understood. The basal metabolism, i. e., the metabolism at rest during fasting, of obese individuals is a little lower than the average of normal individuals, but hardly low enough to constitute any but a contributing cause of the condition. Of course if all fat persons were so constituted as to show a marked reduction of chemical changes in the body, hence less waste, as compared with their normal condition, obesity could be regarded as due to this lowered metabolism. But the difference is not great and since the difficulties of making the comparison are very great indeed, it may be said that no marked difference between the basal metabolism of fat and lean persons has been demonstrated. Nevertheless, even a small tendency toward a lowering of basal metabolism might in the long run, all things being equal, as to food intake, etc., produce obesity. It is well known that fat persons sweat excessively after exertion in a warm atmosphere. This is because a fat person cannot maintain his normal body temperature under such conditions by radiation and conduction of heat from the body alone as a thin person can do, and therefore perspires. A fat person cannot stand heat as well as a thin one, and obesity therefore becomes a predisposing factor in heat stroke.

Fat individuals usually drink considerable quantities of water and restriction of their liquids may bring about an immediate and considerable loss of weight, but it does this only by abstraction of fluid and not by reducing the amount of fat. Fat persons tend to restrict the amount of exercise taken. We have mentioned that lack of exercise is a factor in the causation of obesity. As a person puts on weight, he is apt to become less energetic and as he becomes fatter and exercises less, his muscles become weaker. A vicious cycle is thus set up, tending towards the perpetuation of this condition.

Starvation and Inanition.—The effects of starvation are considerably influenced by the amount of water allowed. Without water, life is much shortened and thirst is intense. Indeed it would almost seem that the body needs water more than food; the prolonged starvation tests undertaken by various hunger strikers of our time has only been possible because sufficient fluid has been given. The rate of metabolism is somewhat reduced during starvation, partly because of lessened activity and partly because of slight actual lowering of the body combustions, but this amount is not great. The starving individual keeps up body heat by burning up his own tissues. Of course fasting produces a gradual and continuous loss of weight, at first relatively rapid, about two pounds per day, later more slowly, about one pound a day.

From a practical standpoint, the subject of partial inanition is more important than that of starvation. By partial inanition is meant that the amount of energy supplied is insufficient to meet the needs of the body. Of course energy has to be supplied by

food, hence inanition may be due to a lessened supply of available food. But it may also be due to an increased burning up or combustion of food in the body or to a combination of the two factors. Finally there is a special type of inanition brought about by the absence in the food of certain vital elements called *vitamines*, the exact nature of which is not well understood and for which the reader is referred to the subject of Diseases Due to Deficient Diets, already discussed. With respect to partial inanition brought on by a lessened food supply, it may be stated that there are a variety of conditions capable of bringing this about. First is actual dearth of food itself from inability to purchase or obtain the same. Then too the fear of pain or discomfort after eating may lead the dyspeptic from any cause to refuse to eat. Finally the lack of food intake may be caused by some actual disease of the digestive organs, which, through obstruction or interference with the process of absorption, will prevent the body from receiving a supply. In a disease like diabetes, the patient may eat a quantity of starch and yet through a fault in his metabolism the whole quantity may pass out of the body as sugar in the urine and be lost.

Partial inanition due to increased combustion of food may be due to excessive movement or exercise where for some reason the increased appetite usually following the same does not occur, or if it does, cannot be satisfied. But usually such increased combustion is the result of disease, such as fevers, in which the body burns up its tissues faster than they can be replenished.

The increased metabolism in certain types of goiter cases has been mentioned, and such patients

are usually thin, i. e., suffering from partial inanition on account of their active body combustions, which are in part due, as before stated, to actual increase of their basal metabolism and also to the restless activity and movements which these patients display.

Chronic malnutrition and inanition from any cause often produce weakness, proneness to fatigue and nervousness. Of course every thin person is not unhealthy, and moderate degrees of thinness as well as fatness are often compatible with health, but when symptoms of weakness and nervousness are present in these individuals a gain in weight is often attended with their disappearance.

Protein Metabolism.—Foods which belong to this important class all contain nitrogen whether they are derived from the animal kingdom, as is the case with meat, or from the vegetable kingdom, as is the case with beans. The proteins in the process of digestion are broken down by what is called cleavage into simple products. In the stomach, substances are formed which have received the name of peptones. In the intestines the peptones are further broken down until they become much simpler chemical bodies to which the name amino acids is given; amino because they contain nitrogen in the molecule. These simpler bodies or amino acids get through the intestinal wall and are absorbed into the blood. Although these amino acids are simpler compounds than the proteins from which they are derived, their chemical structure is too complex to admit of explanation or illustration here. They have been picturesquely and quite properly spoken of as building stones, because from these simple elements the tissues are able to select from the blood

and juices of the body those that are needed to build up their own molecular structures which are being constantly disintegrated by use, i. e., functional activity. The muscle cells build up muscle cells, the brain cells build up brain cells, and so on throughout the numerous and complex varieties which make up the total of the human body. It will be readily understood from this that there are a great many different amino acids to supply all the different requirements of the body. Fortunately, on a mixed diet containing different protein substances, all the different types of building stones will be present and the diet will be sufficient in this respect. But experiments have shown that certain particular foods of protein character may be deficient in their content of necessary amino acids and consequently a diet made up exclusively of such proteins cannot maintain health nor supply all the necessary building material. Some proteins like casein of milk and albumen of white of egg appear to carry all the necessary amino acids, but others like the proteins of wheat grain, corn grain, etc. are deficient in certain amino acids and consequently require to be supplemented by other foods which contain them. The body is totally unable to manufacture amino acids and must, therefore, obtain them in the food.

Much has been said and written in recent years as to the minimum amount of protein food required by the body to maintain an exact balance of the chemical changes or metabolism. Early estimates put the amount at a figure twice as high as more recent ones; that is, it is now known that the equilibrium of exchange of nitrogen in the food and excretions can be kept balanced with quantities of

protein food not over one-third of the amount actually consumed by well-to-do persons. According to some authorities this means that we eat far too much meat; according to others a luxus of consumption is necessary to maintain the body in a fine state of health. A good many people are convinced that meat foods are unhealthy and voluntarily abstain from them entirely. Such persons scarcely consume enough protein to keep their nitrogen balance in equilibrium. They often complain of lassitude, weakness, and early fatigue in work, all of which symptoms usually rapidly disappear if the protein intake is increased.

Fortunately, nature has made our ordinary foods "fool proof" as it were, since, though a person eschews meat entirely and eats only vegetables, if he takes a rich supply of these and includes vegetables like beans among the number, he will obtain a sufficient amount of protein or vegetable-meat as it were to prevent him from starving his tissues to death. If, however, he should be so foolish as to restrict his vegetable food in any degree, particularly if he lives upon corn and wheat alone, he is sure to suffer from inanition with the added imminent danger of a deficient vitamine supply.

Although the fact involves some technical considerations, it may be stated here that the amino acids which are not actually built into the body are finally converted into the substance urea which passes out in the urine. The conversion takes place to a large extent in the liver. By the process the nitrogen is abstracted from the amino acid and converted into ammonia, which unites with the carbonic acid always present in the tissues to form urea. Certain cells can thus form ammonia, which

is a highly alkaline substance, and by means of ammonia the tissues are able to neutralize acid bodies which may accumulate in the tissues under conditions of disordered health, and thus render them innocuous. If it were not for this mechanism the body tissues would soon be poisoned by acid substances which are constantly being formed during the chemical combustions of the body. The accumulation of acid bodies is known as acidosis.

Acidosis (formation of acids in the body).—This subject is too technical to give it any but a brief and incomplete consideration. The chemical changes constantly going on in the body give rise to more or less continuous formation of acids, carbonic acid (CO_2), sulphuric acid, phosphoric acid and lactic acid are among those normally found, and a particular acid derived from fats known as oxybutyric acid may be formed in certain stages of the disease diabetes. Despite the constant formation of acid substances in the body and despite the variations in amount of acid and alkaline substances taken into the body, the reaction of the blood remains constantly neutral or slightly alkaline under all circumstances. The tissues are able to do this by the use of several mechanisms, chief of which are the presence of neutral salts (carbonates and phosphates) in the blood, the elimination of acids through the lungs and kidneys and the power of producing ammonia when it is needed to overcome acid. The presence in the blood of carbonates and phosphates enables it to oppose the effects of the introduction of acid substances.

The acid given off by the lungs is carbonic oxide or carbon dioxide, which passes out as a gas with every expiration. Acid is eliminated from

the kidney in the form of phosphates. When acid-forming substances are taken by the mouth the urine becomes more acid, whereas when alkalies are taken the urine becomes more alkaline. The first effect of an increase of acid substance in the blood is to make the breathing deeper, by which more carbon dioxide is exhaled. If this is not sufficient to get rid of the acid, the tissues contribute a portion of their fixed alkali and also manufacture ammonia, which neutralizes the acid and prevents harmful effects.

CHAPTER XII

THE PREVENTION OF DISEASE

IT IS indeed passing strange that the one subject which everyone ought to study, the subject of how to keep well, is much neglected. There appears to be considerable indifference on the part of many intelligent persons to the proper teaching of the care of the body. Herbert Spencer half a century ago emphasized this fact and called attention to the necessity of putting instruction in hygiene on a high plane among the useful studies. He said in substance that in the order of their importance, the leading branches of human instruction should correspond to the leading branches of human activity. According to his estimate, the leading kinds of activity in human life are several, but at the head stands those which indirectly administer to self-preservation. Consequently, any rational scheme of education must not neglect nor even subordinate instruction in all branches of knowledge which contribute to the preservation of life. It has been said truthfully that "Vigorous health and the accompanying high spirits are larger elements of happiness than any other things whatsoever. Teaching how to maintain them yields to no other." The more we ponder the more we are inclined to agree to the proposition.

Fortunately the instincts provided us by nature are sufficient in many instances to successfully subserve the preservation of life and do it in a more

efficient way than any artificial education could secure. The common animal instincts give warning and provide against gross dangers. The whole period of infancy is given over to bodily growth and development of the varied muscular movements and reflexes which constitute an efficient guard against the menace of outside injuries. Throughout childhood and youth there is a further development and perfection of these adapted mechanisms. But as the individual grows into adult life, especially up to puberty with its accompanying development of the sexual instinct, the situation in respect to health and happiness becomes rapidly more complex. Added to this are the enormous complexities of social life, against whose evil influences where they exist there is no innate instinctive protection. Protection must be obtained through education, or through sorrowful experience or both. It is a sad commentary upon life that so much misery and disease arise from ignorance and transgressions of the physiologic and hygienic laws of nature. But the fact that such is the case affords the most potent stimulus toward learning what these laws really are and teaching ourselves to obey them. It is said that a thoroughly well person after middle life is the exception and not the rule. Surely we ought to struggle to overcome such melancholy fact if it be true. Of course no amount of study or scientific culture nor education in hygiene carried to its highest possible state of perfection can eliminate disease and death entirely from the world, but it should be the desire of everyone to see these efforts extended and enlarged.

Concerning the teaching of personal hygiene in the schools, there is no doubt that it is too much

neglected. Personal hygiene is applied physiology and a proper understanding of the latter must be acquired before a really intelligent application of the principles of the former can be made. A proper knowledge of the normal functions of the body and the simple methods of keeping them always in healthy activity is something that every educated person should possess, yet it cannot be denied that less attention is paid under our educational system to these essential matters than to subjects of less importance. Spencer once said: "While anxious that our sons should be well up in the superstitions of two thousand years ago, we care not that they should be taught anything about the structures and functions of their own bodies—nay, would even disapprove of such instructions. So overwhelming is the influence of established routine; so terribly in our education does the ornamental override the useful."

Nevertheless, it must be admitted and emphasized that to make the teaching of physiology and hygiene truly useful to those who are to receive instruction, great care must be taken to see that it is done at the proper age, in the proper way, and by those really qualified to teach. It has been well said that "in literature and lectures on hygienic subjects too often the science is made too popular or the popular exposition too scientific." There has also been too frequent a tendency to present as much of the gospel of health as may be put in a popular form, or that for ulterior motives the laymen may be induced to accept. Such an attitude can only weaken the cause of preventive medicine among intelligent persons. It is not desirable to produce athletes, physical culture fanatics, or practitioners of newfangled and

erratic systems and "pathies." What is needed is simple instruction by capable teachers in the proper care and use of the body, authoritatively based upon the best available modern anatomic, physiologic and hygienic data. We should not have "every man his own physician" as seems often the subject in lectures, periodicals, and books relating to health; rather give every man fundamental knowledge that will enable him to understand and if necessary to formulate the requisite rules of health and to distinguish scientific medicine from quackery. Stripped of its superfluous technicalities this knowledge may be imparted to anyone of average intelligence and education and it is desirable that more literature and personal explanations in this direction should come from the medical profession and not be left entirely in the hands of lay teachers and writers.

THE PREVENTION OF GERM OR INFECTIOUS DISEASES

Theoretically the prevention of infectious diseases consists of keeping certain germs out of the body, for if we knew how to absolutely exclude them, there could be no germ diseases. But although we cannot entirely eliminate these invisible foes, we have advanced a long way ahead of the ancients in combatting them. Naturally the ancients could do little, for they did not even know of the existence of germs. When the Greeks were besieging Troy we learn that a great plague attacked them. They believed the cause of the plague was the sun's rays and that the Sun God Apollo was angry and was shooting his arrows against them. Formerly in Africa where epidemics of smallpox appeared, the natives built fences across the forest paths because

they believed that in this way they might prevent the monster which they pictured in their imaginations as causing the disease, from entering the community. Even as late as 1854 and in our own country, when a great epidemic of cholera appeared, the people believed that the disease was spread through the air and for many years after that, malaria was considered to be due to bad air and spread in the same way. By discovering germs and identifying many infectious diseases with their proper cause and by studying the habits and characters of the germs themselves, science has been enabled almost in a generation to turn the table upon germs and wage a really effective campaign against them. Naturally, in a book of this size only a few of the most important infectious diseases can be mentioned and their prevention discussed.

TYPHOID FEVER

Mankind has suffered terribly from this disease. In our own country in recent times, typhoid fever held fourth place in the mortality list. Every year over 35,000 people died of this disease, chiefly persons under 35 years of age. Nearly half a million people contracted it annually. In the Spanish-American War twenty per cent of all our soldiers contracted typhoid fever and over 1,500 died. Up to very recent times, this disease was one of the most frequent infections which doctors were called upon to treat. So important was it regarded that in every textbook upon practice of medicine typhoid fever was the first disease described and this description occupied the largest space. Now all is changed. Cases of this disease have become much rarer and it is almost impossible to provide a

sufficient number in a general hospital to give the internes and students an opportunity to become acquainted with the disease.*

Persons who have recovered from the disease and still have typhoid germs swarming in their stools or urine are called "typhoid carriers," and it has been demonstrated that such "carriers" are potent disseminators of the disease, for years even, after the termination of the symptoms. The contamination of the drinking water of cities and towns was long ago found to be one of the important causes of the spread of typhoid fever and it was demonstrated in many countries and localities that an improvement of the water supply always led to an abatement of the disease. But never did the one act of rendering the water supply pure and free from typhoid germs succeed in totally eliminating the infection. The milk supply, the ice supply, the food supply all required attention. In the effort to keep the food supply uncontaminated the war against the fly was begun when the rôle which these filthy little scavengers play in the spread of typhoid fever came to be appreciated.

The germ of typhoid fever enters the body through the mucous membrane of the intestines, multiplies in the blood stream and locates in different organs of the body. The germs always have a predilection for the lower end of the small intestine, particularly in certain glandular tissue agglomerations somewhat comparable to small tonsils embedded in the mucous membrane and called the patches of Peyer. These patches are most numerous in the lower two feet of the small intestine

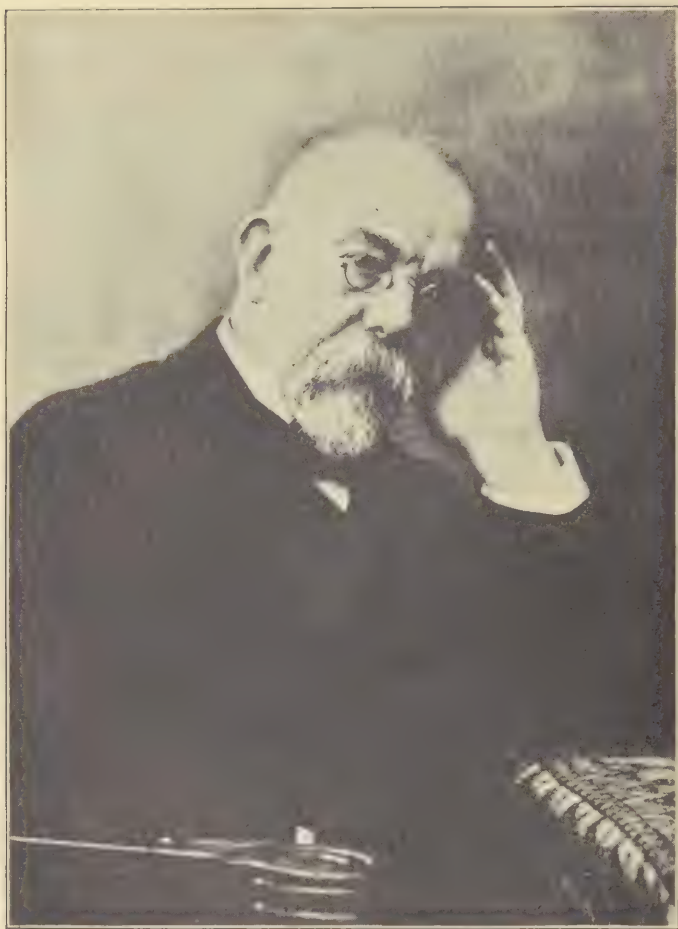
* There are indications that typhoid fever is again on the increase.

where it joins the large bowel at the ileocecal valve. These masses of tonsillarlike tissue are especially involved in typhoid fever. They become swollen and ulcerated and the most dramatic and fatal catastrophe to be observed in this dreaded disease occurs when such ulcers gradually deepen, finally perforating the bowel wall and the putrid poisonous contents of the intestinal canal seep into the abdominal cavity and set up a violent and usually fatal peritonitis.

Every case of typhoid fever is reported to the health authorities, who see that the case is quarantined or isolated. All excreta from the patient are destroyed and before he is allowed to mingle freely with people after recovery, he should be examined to see that he is not a "typhoid carrier." Pure water, pure milk, and no flies and the elimination of the carrier will prevent the spread and ultimately extinguish this dread disease. In recent years vaccination to prevent typhoid fever has been extensively practiced, especially in military life. Typhoid fever did not figure highly in the morbidity or mortality of the troops who fought in the great World War. But while typhoid fever has almost disappeared from the vaccinated military personnel it has done the same thing among the unvaccinated civil population.

LOBAR OR CROUPOUS PNEUMONIA

Acute lobar pneumonia is one of the commonest and most fatal of infectious diseases. Though a disease of the lung primarily, in that its principal physical manifestations are there located, yet it begins as a general infection or septicemia. For some unknown reason the germ pounces as it were upon the lung tissue apparently in preference to that of



ROBERT KOCH



Wm Osler

Write me as you find time to fill in

WILLIAM OSLER

other organs. The germ of lobar pneumonia (pneumococcus) is a microorganism which belongs to the class of round germs called cocci and it has a special lancelike shape. It is almost a constant inhabitant of our mouths, so much so that when it is desired to study the germ in the hospital, all that is required is to collect spittle from the mouths of a dozen persons indiscriminately and this mixture if injected in even very small amounts into a susceptible animal, such as a rabbit, will set up an acute fatal pneumococcus septicemia (blood poison). Modern investigators have found that there are different strains of this germ, some much more virulent than others.

Lobar pneumonia is an inflammation of the walls of the air sacs of a part of the lung accompanied by an oozing of inflammatory material into the air sac itself, which congeals or clots, thus preventing the entrance of air into the affected part. The lung becomes solid like liver and is thus said to be hepatized. Usually a whole lobe, say one-third or one-half of the whole lung on one side, is involved. The most important factor in the prevention of pneumonia is the bodily resistance. If this is kept uniformly high, the individual is not apt to contract it. Consequently, everything which tends to lower resistance must be scrupulously avoided and the greatest care taken to avoid exposure and fatigue during times of epidemics. Pneumonia patients require isolation and the disinfection of their sputa.

TUBERCULOSIS

From earliest times mankind has been afflicted with tuberculosis. Hippocrates, the father of medicine, wrote a treatise on consumption 400 B. C.,

and in the lungs of Egyptian mummies the scars of tuberculosis are said to have been found. The germ of tuberculosis may be said to be the chief, the archenemy of mankind. Taking all of its many manifestations together, it kills more persons than any other one disease; one-seventh of all the deaths in the world from every cause are due to some form of tubercular infection. In the United States alone between a fifth and a sixth of a million persons die annually of the disease. But black as this may appear, the situation has been worse and the fight against the so-called "white plague" has accomplished much and nothing is more certain than that gradually the upper or whip hand will be gained by those who are directing the combat and that finally tuberculosis, the monster enemy, will be conquered. This optimistic view is based upon the knowledge that already through systematic efforts the death rate is declining. The slogan which is imprinted upon the battle flags of antituberculosis warriors is "Cleanliness," and nothing is more certain than that when the world is really clean tuberculosis will disappear. The germ cannot live except in filth and darkness. Tuberculosis is spread mostly by the germs in the sputum of those who have the pulmonary form of the disease, though any other discharges, as from a tubercular abscess or tubercular intestine, may do the same.

One of the greatest difficulties encountered in the campaign against tuberculosis, as in fact of every other communicable disease, was lack of education. All the world had to be taught the known facts of the disease; the germ, its character, its mode of spread, its fearful potency for evil, so that every individual in every community might do his little bit

in helping to check it. This may be said to have been fairly well accomplished at the present day and there is a general acceptance on the part of the public of all accessory measures required to stamp out tuberculosis, even though they may in certain instances appear to restrict the liberties of individual persons. It is generally recognized, and that too very fortunately, by the unhappy victims themselves, that everyone sick and well will be benefited by the prevention of the spread and dissemination of sputum loaded with the consumptive germ. Thus the old days of indiscriminate spitting about the streets, in the houses, and public buildings seems gone forever. The people have learned that sunshine will quickly kill the germ and that dark, damp rooms favor their growth. Hence the success and popularity of open air campaigns which now have the support of everyone. The social conscience has awakened and the sweatshop and dark tenements are going forever if they have not already gone. It has been said and probably truthfully that if for two generations only, all consumptives would destroy their sputum, the third generation would know the disease by name only. The fact is that one generation is now attempting to do this and already the decline in consumption has begun in earnest and is becoming more apparent every decade. The death rate from tuberculosis in some cities is less than half what it formerly was. Seven years have actually been added in our own country to the average age of its inhabitants. And what is especially heartening and encouraging indeed to those unfortunates who have not escaped is that four-fifths of the cases, or eighty per cent, if they can obtain the benefits of modern treatment strictly

carried out under proper environment, get well by an arrestation of their disease, complete enough to enable them to once more take their place in life among the active workers.

The germ of tuberculosis is one of the germs of which we know the most because of the immense amount of study which has been put upon it since its discovery by Robert Koch in 1882. The bacilli, as they are called because of their rodlike shape, are easy to find, especially since Koch discovered that they retain their color when stained with certain red dyes like fuchsine and then treated with acid which will bleach the color from all other germs. In the parlance of the dyer they are "fast." The sputum of a consumptive is loaded with these germs. An average patient may throw out of his lungs from one to four million of them daily. When the sputum dries, the germs are carried by the dust into the air we breathe and thence into our lungs. If it were not for the great ease with which the sun's rays kill tubercle bacilli, we would all become infected. Wherever the gorgeous rays of the sun can penetrate and do penetrate, there the tubercle bacillus is killed. Besides this fact it is undoubtedly true that individuals differ greatly in their susceptibility to the infection. We inherit as it were a resisting or nonresisting soil chiefly from our mothers. Each individual may retain his resistance or greatly increase the same by a proper mode of life. Outdoor régime, plenty of exercise, food, and sleep and hygienic living afford the greatest insurance against infection by consumption germs. Certain diseases have a marked tendency to bring on consumption. Among these are measles, whooping cough, typhoid fever, smallpox, and some chronic diseases.

But notwithstanding what we do very many people acquire a local tubercular infection somewhere in their bodies at some time during life and get well without being aware of the danger through which they have passed. This is proven by the fact that autopsies upon many thousands of persons dying of all sorts of diseases have disclosed, in a very large percentage of these, some slight tubercular lesions, walled in by nature so effectively as never to have been able to spread.

What is a tubercular lesion? A tubercular lesion, called a tubercle, is a little tumor or hard lump formed in the tissues wherever the tubercle bacilli get a foothold. It may be very small, at first hardly or barely visible to the naked eye, but as these small tubercles multiply or coalesce they eventually form good-sized masses surrounded by a wall, with a cheesy center when cut through with a knife. The cheesy center may become impregnated with lime salts and become calcified so that it grinds when cut and this is one method of cure. Or it may break down into a soft liquid material which upon being expectorated leaves a hollow cavity. If the hole fills up it leaves a scar. One of the chief characters, therefore, of the tubercle bacillus is this tissue-killing or necrotizing power and upon this fearful attribute its melancholy results depend. It should always be remembered that most cases of consumption are contracted by living with consumptives. It is now known that when several members of a family die of consumption, the trouble is not a matter of inheritance, but of intimate association and prolonged exposure to the germ.

The destruction of consumptive sputum is the greatest single factor which has led to the notable

reduction in the number of cases of tuberculosis in recent years. Not one-third as many people are dying of tuberculosis now as died of it half a century ago. In other words, the future prospects of conquering this disease are brighter than they have ever been before, and since the campaign against the Great White Plague will be unremitting there is every prospect that the disease will almost if not entirely be extinguished.

INFLUENZA, GRIP, "THE FLU"

This disease sometimes spreads with alarming rapidity throughout the world, in true pandemic form, affecting as high as two-fifths of the population of the invaded countries. Only lately has such a pandemic occurred, following in the wake of the great World War. The great pandemics of influenza appear to be separated by intervals of several years. In December, 1889, influenza broke out in Western Russia and spread over the world. The author well remembers this pandemic, as he was an interne in a general hospital at the time. After the subsidence of this pandemic, return epidemics broke out in our country in 1890 and 1891. In this respect it resembled the previous epidemics of 1729, 1788, 1830, and 1848, all of which were followed by secondary outbreaks.

During the summer of 1918 epidemic influenza appeared in Spain, from whence it spread to Austria, Germany, France, England and the United States. The epidemic made its first appearance in our country in Boston. In a short time it had assumed gigantic proportions. The epidemic of 1918 spread over the country as a plague of unheard-of virulence from mid-September to the end

of October. The bulk of the cases were of the respiratory type and the chief complication was pneumonia. The death rate was high, especially in the young. It attacked the army camps with whirlwind force.

We always have so-called sporadic cases of influenza in almost every community, at different seasons of the year, and frequently more or less widely spread epidemics will occur. The great pandemics of the disease appear to be separated by intervals of several years.

The germ of the disease is a small bacillus discovered by Pfeiffer and Cannon in 1892. It appears to be ubiquitous, i. e., found everywhere, and is a very frequent inhabitant of the respiratory organs of individuals along with other germs and accompanying many diseased conditions such as bronchitis. In fact, the germ of influenza generally attacks first the respiratory organs, though it is by no means averse to doing damage in other situations (nervous, digestive systems).

It produces, therefore, as a rule, symptoms which will be referable to the air passages. At first there is apt to be a cold in the head, so-called coryza, followed by bronchitis. There will usually be considerable weakness accompanying these conditions. Indeed a degree of debility and prostration out of all proportion to the bronchial manifestations present is a distinctive characteristic of influenza and has given the disease its popular designation of la grippe.

So far, no successful methods have been discovered to prevent the spread of epidemics of influenza. Individuals should avoid contact with infected persons as far as possible.

DIPHTHERIA

The germ of this dangerous and once much feared disease is a rod-shaped organism called bacillus of diphtheria. It attacks the mucous membrane of the throat, pharynx or postnasal space by predilection and so intense and destructive is its attack therein that a high degree of inflammation is set up. A whitish or grayish white leathery skin or membrane forms upon the invaded parts, which can only be removed with some difficulty by swabbing and then only by abrading the tissues with the production of some bleeding. The dangerous and lethal tendency of the germ is due to the fact that a poison or toxin is freely elaborated by it as it grows and this toxin, being soluble and diffusible, soon gains entrance into the circulation and is carried throughout the body.

The germs do not tend to travel with the same facility as the poison and for the most part remain at the place originally infected. It is the toxin circulating in the blood which causes the general symptoms of diphtheria.

The modern treatment and prevention of diphtheria is an instance of effective specific therapy (treatment). The discovery of diphtheria antitoxin marks the epoch of the high-water mark as it were in serum therapy. There is no other example in medical practice of a serum endowed with such unmistakably favorable influence upon the objective phenomena of infectious disease. Its discovery raised the hopes of medical men to dizzy heights only to cast them down again, for since the researches of Behring in 1890, upon which the great and final work of Roux in 1891 was founded, no

other instance has been developed of an antitoxic serum endowed with anything like equal powers. But we may be truly thankful that the biologic conditions which exist in diphtheria are of such a nature as to allow of the manufacture of an efficient antitoxin or neutralizing substance.

Since the introduction of diphtheria antitoxin the great dread of the disease which everyone whose memory goes back a quarter of a century can recall, has almost disappeared. Before the days of antitoxin almost fifty per cent of the cases died. Gradually the mortality has diminished until it has reached the comparatively low figure of ten per cent. This great reduction has appeared to evolve *pari passu* with the improvement and extension of the use of antitoxin, with increased doses and early administration. It may be that other factors have contributed their part to this encouraging result, but antitoxin may safely be regarded as the biggest factor. Finally it may be said that the highest point of efficiency in the use of antitoxin has not been reached.

Diphtheria antitoxin is made by injecting a horse or other suitable animal with gradually increasing amounts of the poison or toxin secreted by the germ of diphtheria, obtained in cultures of the microorganism. The horse reacts by gradually producing antibodies or so-called antitoxin in his own blood and this can be obtained by bleeding the horse after an appropriate interval and obtaining the serum from the blood. Methods have been well worked out whereby the potency or units of antitoxin present in a given serum can be determined, and thus the dose can be fixed.

In an ordinary case of diphtheria from six thousand to ten thousand so-called units are injected as

soon as the case is seen. This is followed if necessary by frequent doses of equal or greater size until the membrane is seen to disappear, which it usually promptly does. In laryngeal diphtheria or croup, twice or thrice as large doses are administered and in desperate cases, doses up to one hundred thousand units are given. In fact, the rule is nowadays to give the remedy in doses large enough to produce the desired physiological effects. Some disturbances such as joint pains, skin eruptions, etc., may be produced by the serum and very rarely, more serious phenomena are encountered, but these objections cannot be allowed to weigh against the great goal to be sought; this is, to neutralize all of the poison or toxin secreted by the dread germ and to inhibit the growth of the organisms themselves.

Diphtheria antitoxin is also used as an effective means of preventing the disease in those who have been exposed to the possibility of acquiring it. The so-called preventive or immunizing dose is much less than the curative dose, usually ranging from five hundred to one thousand units. The immunity thus produced is unfortunately ephemeral in duration and careful isolation of the infected individual until all organisms have disappeared from the throat, still remains the most effective means of preventing the spread of the disease.

TETANUS OR LOCKJAW

The germ of this disease is also a bacillus or rod-shaped organism. It has a peculiar lump on one end which gives it a characteristic appearance. This dread germ lives normally in the intestinal canal of cattle and is deposited in the superficial layers of the soil by their manure. There is always

a special likelihood of lockjaw in cases where wounds are received in or about stables where cattle are sheltered. In the highly fertilized soil of north-eastern France and Flanders, myriads of these organisms abounded and at the beginning of the great World War one of the first problems which arose was to combat this infection in wounded soldiers.

The tetanus germs, like those of diphtheria, stay in the place where they first find lodgment and do not tend to invade the blood. Their deadly toxin, many times more poisonous than strychnine, gains access to the nervous system where it produces its deadly effects.

We possess an antitoxin which is very effective in neutralizing the poison of the germ if it can be brought in contact directly with it. The antitoxin of tetanus is much more effective in preventing than in curing the disease. After the spasms have developed from the fixation of the poison in the nerve tissues the antitoxin has but little effect.

MALARIA

Since the transmission of malaria by means of mosquitoes has become known and understood, its prophylaxis or prevention has become simply a matter of their destruction or the prevention of their bites. The campaign against mosquitoes has been carried out so successfully, that even certain countries and districts which formerly had the unenviable distinction of being infested with the disease, have been converted into salubrious territory.

Mosquitoes bite after sundown, therefore in regions infested with anopheles,* persons must pro-

* Name of malaria-bearing mosquito.

tect their domicile with screens to prevent the disease-laden pests from entering. Best of all, a study of the habits and mode of breeding of mosquitoes taught sanitarians the means of preventing their multiplication. This takes place especially in little pools of stagnant water where the eggs are laid and the larvæ grow. The simple process of draining these pools, or covering them with kerosene so that the larvæ are destroyed, acts magically in cleaning up a malaria-infested district.

Just as typhoid fever has become a much rarer disease than formerly, so also has malaria. In Washington, the capital of our country, once surrounded by marshes, where the writer can well remember in the early days of his practice seeing even suckling babes shivering with malarial chill while nursing at their mother's breast, the dread disease has become almost extinct. Weeks go by without a case in the hospitals, and the sight of malarial blood under the microscope swarming with parasites of the disease has become so rare that the medical student of to-day is forced to get his information on the subject more from illustrations in books than from pictures of actual life.

The vast improvements in sanitation throughout the civilized world have conquered the disease. The mosquito, little buzzing pest, whose bite was rightly considered torture enough for the unlucky victim of attack, has been found to be a mortal enemy of man and his indiscriminate destruction therefore a part of man's duty to himself.

Under "Yellow Fever," more is said upon this subject of mosquito destruction, from which it can be fully appreciated how medical science and sanitary engineering, working hand in hand, have eliminated

disease and death, and have extended the benign spheres of man's activities into regions where heretofore the specter of death in the form of the tiny mosquito hovered always before him.

EUROPEAN SLEEPING SICKNESS; ENCEPHALITIS LETHARGICA

Following the recent great pandemic of influenza, which spread over the world in the autumn of 1918 another curious epidemic disease made its appearance to terrify the world, already overcome by its devastating predecessor. This disease, which has been rather picturesquely, if a bit inaptly, termed "sleeping sickness," began in Austria as early as 1917, but did not become extensively distributed until early in 1919. It spread rapidly over Europe, including Great Britain, and by the spring of 1919 had appeared in all parts of our own country. Africa and Asia were simultaneously invaded.

Epidemics, like comets, are not new. This strange disease was in reality no stranger. Descriptions of epidemics have come down to us from the time of Hippocrates. Celsus, who lived in the time of the Roman Emperor Augustus, likewise recorded its presence in Rome. Toward the middle of the seventeenth century, Sydenham described cases and gave it the name of "comatose fever." Stahl, in 1779, wrote an accurate casuistic account of it and at different times throughout the nineteenth century various epidemics were recorded.

There is truly "nothing new under the sun," but when the epidemic or pandemic of this disease struck the world, as it were, in 1919 it took the medical world by storm and surprise. Most physicians had never seen it before.

This strange disease begins usually with fever and delirium, followed by muscular twitchings, then drowsiness, somnolence or coma. There are various fleeting paralyses. Although following influenza in many cases, it is a distinct disease. About a third of the serious cases die and those who recover, usually after a long convalescence, suffer from asthenia (weakness) and are for a long time unfit to follow their avocations.

Its causation is not known, but it is believed to be due to some form of extremely tiny organism which affects the blood vessels of the brain, causing a multitude of small inflammatory deposits in many situations.

At present the disease appears to be disappearing as mysteriously as it came.

With reference to its prevention, little is known, since we are entirely ignorant as to its real cause. Flexner states "that special efforts should be made to determine the existence of and to detect and control the milder, walking or abortive cases, since they are more likely to spread the disease than the outspoken lethargic and paralytic ones. Since the secretions of the nose and throat have become suspected of harboring the morbid agent, adequate measures of controlling the distribution of these secretions should be carried out."

PREVENTION OF DISEASE THROUGH PERSONAL HYGIENE

When we come to consider the prevention of diseases other than germ diseases we enter a territory in which the difficulties and lack of exact knowledge make it impossible to arrive at perfectly definite conclusions.

Heredity and environment exercise their constant though mysterious and not adequately understood influences both to produce and to prevent disease. It may be fairly said that the science of medicine is to-day sufficiently advanced to supply the trained physician with many potent weapons and means, by which a successful effort may be made in many cases to prevent the development of particular diseases in particular cases. To describe these methods in detail would involve the consideration of each particular disease, which in a work of this character would be manifestly impossible.

Every individual, however, can, if he will, diminish the likelihood of becoming ill by familiarizing himself with those facts which are grouped under the subject of Personal Hygiene, and to a consideration of the questions which come under this head we now come.

Exercise.—The effects of exercise on the body are as follows: (1) Increased force and frequency of the heart's action and consequently an increased circulation of blood through all parts of the body; (2) quickening of the breathing, which causes an increase in the amount of air respired and consequently an increased elimination of carbon dioxide; (3) heightened action of the skin with increased perspiration, dilatation of the blood vessels of the skin, evaporation of sweat and consequent radiation of larger amounts of bodily heat; (4) increased circulation through the muscles and consequent improvement of their nutrition.

Exercise, therefore, means muscular action and involves more rapid combustion, that is, burning up of waste bodily tissue, with increased elimination of carbonic acid gas and water. Thirst and appetite

are therefore increased by exercise and water and foods are required to supply the waste of tissue and dissipation of energy.

Regular exercise in the open air, while necessary for all, is most essential to brain workers to purify the blood of waste matters, to stimulate the action of the bowels and to insure the healthy performance of all functions of the body.

Well-developed muscles are, of course, requisite for all bodily movements, but overdevelopment of certain groups of muscles such as are seen in gymnasts should not be sought for by the average individual. The aim should be to encourage general strength and activity rather than to aim at special expertness in feats of strength. For this reason the natural exercises such as walking, running, rowing, horseback riding and various games like fencing, boxing, etc., are best. Games also inculcate courage, control of temper, self-restraint, and discipline, combined with the laudable desire to win fairly.

After exercise is concluded, the body should be bathed, using soap and water to remove secretions from the skin, which if left to dry thereon render it dirty and damp, thus increasing the likelihood of chilling and catching cold.

Exercise should not be too severe and in each individual should be graduated to conform with the physical conditions of resistance. Following too strenuous exercise the heart is overstrained, as shown by breathlessness, palpitation and small, rapid, irregular pulse. It would appear that gymnastic exercises which involve fixation of the chest for more than a few seconds and consequent arrest of breathing are especially liable to produce heart

strain with dilatation (acute enlargement) of the heart. Congestion of the veins and lividity (discoloration) of the face during muscular effort indicate that the exercise is producing heart strain. Since the abandonment of gymnastic exercises in the army, with the substitution of Swedish movements and the elimination of fixation of the chest in drill, cases of heart disturbances are much fewer than formerly. Physical training exercises which interfere least with the normal movements of breathing and which do not necessitate positions or postures which produce strain and tension of the body are the most suitable for the young of both sexes. All muscles require rest following exercise, the heart particularly.

It has been shown by calculations that an ordinary day's physical work for a healthy man is equal to raising three hundred tons one foot, or three hundred foot tons. This amount of work can be sustained indefinitely. Work represented by four hundred foot tons or over daily is excessive and will require much increased intake of food. A man walking on a level surface at the rate of three miles per hour does work equivalent to lifting his own weight one-twentieth of the distance traveled. At quicker rates of speed, the work increases until at eight miles per hour he does work equivalent to raising his weight one-tenth the distance traveled. If a man weighing one hundred and fifty pounds walks seventeen miles at the rate of three miles per hour the work done will be three hundred foot tons.

In standing and walking a correct carriage should be assumed. One should "stand tall," thrusting the top of the head as high as possible; the chin should be held close to the neck and the abdomen kept in.

High heels, which were introduced by Louis XIV of France on account of his low stature, are bad. A good shoe should have a wide low heel. It should not bend the big toe around toward the other toes but allow it to extend in a straight line with the inside of the foot. It should be wide enough to allow the toes and foot to spread in walking and in standing so that the natural points of support of the foot are used. It should be long enough not to cramp the toes and should have a box high enough to prevent pressure on the toes, causing ingrowing nails and corns. It is important that the shoe be so built that a straight line through the center of the heel will run through the center of the toes. In walking, the toes should not be turned markedly out, which tends to increase the stress on the inner side of the arch.

Clothing.—A man in the cold arctic region will lose much more heat than one in the tropics. The temperature of the body, however, all over the world is the same; about 98.6 degrees Fahrenheit. A person exercising violently produces five or six times as much heat as a resting person does. The great purpose of clothing is to protect us from cold. It has many other uses, of course, one of which has been apotheosized by Carlyle in his famous *Sartor Resartus*, wherein it is shown that the almost divine sentiment of shame had its origin in clothes and not vice versa. Proper clothing protects the body from the danger of chilling, which, by driving the blood into the interior of the body, predisposes to colds, influenza and pneumonia. Since wet footwear takes the heat out of the feet the wearing of rubbers in wet weather is a great protection against cold. Proper clothing also protects the body against over-

heating, which latter also lowers resistance to disease, particularly diarrhea, dysentery and other gastro-intestinal disorders.

The ordinary garments of civilized man are made either of one, or a mixture of two or more, of the following materials: cotton and linen from the vegetable kingdom; wool and silk from the animal kingdom. Cotton garments are durable and do not shrink in washing. They are nonabsorbent and rapidly conduct away heat; hence cotton is usually the wrong material for undergarments, for it soaks up the perspiration, causing chill to the surface of the body. The heat of the body is not retained by cotton, but is rapidly dissipated.

Linen materials have a very fine, smooth and close texture. Linen is, like cotton, a good conductor of heat and a bad absorbent and retainer of moisture and is generally unsuitable material for underclothing. Wool forms a valuable material for clothing. It is an extremely bad conductor of heat and is very absorbent and retentive of water and moisture, hence its value as a material for underclothing. Being a nonconductor, wool is warm by preventing the dissipation of the bodily heat. After exercise causing perspiration, the moisture is absorbed and retained by the wool, and the vapor is condensed, thus giving back to the body the heat rendered latent by evaporation from the surface of the skin. A woolen garment after exercise is therefore warm and dry and prevents the chilling of the surface from the lowering of the temperature by evaporation, which is so dangerous. In hot climates, especially, wool should be worn next to the skin to ward off those chills which are often the forerunners of dysentery, diarrhea and ague. One disadvantage

of wool is its hardening and shrinkage when frequently washed, particularly in strong soaps, and the consequent loss of absorbency. Woolen garments should be frequently washed in soft, cold or tepid water with mild soap, free from soda, and should not be much wrung out. Flannelette is a highly inflammable cotton material, popular because of its warmth and cheapness. It is sometimes rendered noninflammable by previous treatment, but frequent washings remove this quality and the material again becomes as inflammable as before. Many lives have been lost by its inflammability.

Silk is a bad conductor of heat, but less absorbent than wool. It is more cleanly and shrinks less than wool and is less irritating to the skin, but it is expensive in first cost and is less durable than either cotton or wool. In hot climates the outer garments should be white or gray to protect from the direct rays of the sun. Children and old people require especially warm clothes. In children the bodily surface is greater in proportion to bulk than in adults, hence radiation of heat is proportionately greater. Children should wear woolen material. All parts of the body should receive protection. Old people have feeble circulation and combustion and chilling is very apt to depress the vital functions.

A good material for clothing purposes should meet the following requirements: It must afford proper protection against cold and heat; it should interfere as little as possible with natural functions of the skin; it must exert no irritating or poisonous effects upon the skin; and it must not be highly inflammable. Clothing is warm in proportion to its capacity for retaining the natural heat of the body and therefore the materials which are the worst

conductors are the warmest. In the order of their warmth the materials in common use are, wool, fur, down, silk, cotton, linen. The color of outer clothing has some importance for the reason that white reflects light while black absorbs light and turns it into heat. The order in which different colors absorb heat are as follows: Black, dark blue, light blue, dark green, turkey red, light green, dark yellow, pale straw and white. Fabrics which are porous and rough are warmer than the opposite. The order in which various materials absorb water is as follows: Wool, fur, eider down, silk, linen, cotton.

Women's dress as a rule provides a very unequal distribution of warmth. The upper part of the chest and the legs are unduly exposed, whereas the body below the chest is almost overprotected by the corset. The habit of exposing the bare legs and arms of infants to the vicissitudes of the weather and swaddling their bodies with many layers of clothing is to be deprecated.

The head covering should be light. Males are apt to wear too tight hats which by restricting circulation predispose to baldness. There should be no constriction of the neck. Tight lacing is distinctly bad, as it leads to dyspepsia, malnutrition and circulatory disturbances as well as actual deformity of the viscera in aggravated cases. Women should protect their lower limbs in cold weather with bloomers and warm stockings. Something has been said above in reference to hygienic footwear.

As a general proposition it should be remembered that clothing should not be changed according to calendar as many foolish conventions, often inspired by tradesmen, endeavor to enforce, but according

to the weather. It is a fact that clothing worn in successive layers is warmer than when a similar weight of material is applied in a single layer.

Care of the Skin.—The skin regulates the temperature of the body by surface radiation and evaporation. It constitutes also an important means of excretion of fluid and other substances which escape from the numerous or innumerable glands which lie embedded in it and open by little ducts upon its surface. Perspiration or sweat is a slightly acid fluid containing about two per cent of solid matter chiefly common salt held in solution, and various fatty acids and fats. Fatty substance (sebum) is excreted from the skin by special glands known as sebaceous glands. The function of this fat is to keep the skin and hair smooth, moist, supple and protected. In all animals some mechanism is provided by nature whereby fatty or oily material may be spread upon exposed surfaces of the body. In all fowls we see a special organ, situated usually at the end of the spine, whose function is to secrete an oily substance which is voluntarily and instinctively conveyed to the feathers by the bill of the bird. The skin is therefore constantly exuding material which collects upon it, forming with the dying scales of the skin a scurf which must be periodically removed. The penetration of this material into the clothing next to the skin soils the same and renders necessary their periodic change.

A dirty skin and soiled clothing are alike disgusting to the esthetic sense and injurious to the health. We observe every kind of animal making frequent efforts to keep their outer covering of skin, fur or feathers clean and we may well not only imitate but improve upon their example.

Foul and decaying matters on the body increase the liability of infection of the skin, hence predispose to acne, boils and carbuncles and even to more serious invasion of the blood by germs. Uncleanly persons are more liable to chill since their skins are damper than those whose skins are clean; the former being a good conductor of heat, hence leading to surface chilling and the catching of cold. Too frequent application of strong alkali soaps and hot water to the skin, however, is deleterious through the removal of all of its natural protective fats. A dirty skin and clothing predispose to infection by lice. Bubonic pest or plague is spread uniquely by these insects.

For young children with delicate sensitive skins, superfatted soaps containing no free alkali are often desirable. In very hot and very cold countries the natives often anoint the skin with oils which protect from the burning rays of the sun in the one case and the radiation of bodily heat in the other.

After a bath the skin should be rubbed dry with a rough towel. This removes scales or dead skin and stimulates the circulation by dilating the superficial blood vessels.

While the chief use of the hot bath is for purposes of cleanliness it also has in many cases a sedative effect upon the nervous system, allaying restlessness and excitability and promoting sleep. Indeed in cases of severe nervous excitement as in states of mania, hypomania and delirium patients are often immersed for long periods of time in a continuous warm or tepid bath, which has a wonderful sedative effect, far superior to and safer than the exhibition of hypnotic drugs.

Hot baths are best taken at night rather than in the morning, as the body is rendered sensitive to changes of temperature. After hot baths it is always best to throw cool or cold water on the skin prior to rubbing to diminish the chance of catching cold. Cold baths are less cleansing but more stimulating than hot ones. The cold bath is usually taken in the morning on arising and if it is followed by a feeling of warmth and exhilaration after rubbing, it is healthful. The temperature of the water should be regulated to suit the age and strength of the individual and should never be prolonged until a sense of chill is experienced.

Sea bathing is stimulating and beneficial to the majority of persons, but should not be indulged in until at least two hours after a meal. Daily cold baths are not to be used in very young children nor in persons after middle life.

It is wise to wash the feet, the armpits, groins and space between the thighs daily. The head may be thoroughly washed once a week. The nose is best cleansed with a soft handkerchief and clear water, followed by blowing. This removes dust, soot and mucus charged with germs deposited from the atmosphere.

Care of the Teeth.—Dental caries or decay is present in the teeth of over 80 per cent of all school children. Examination of thousands of children show that over 90 per cent are in need of dental care. The majority of young people lose their first permanent molars before they are twenty years old. No other part of the body is so often defective as the teeth. Caries is due to the presence of acid substances elaborated by fermenting carbohydrate (starch-sugar) food retained between and around the teeth, gradu-

ally disintegrating the hard enamel covering and exposing the softer dentine to the effects of germs. This process spreads and eventually results in the destruction of the tooth. When caries is established, chewing or mastication is interfered with, there is pain and consequent indisposition to eat. Pus forms and is swallowed, the breath becomes offensive and gradually the nutrition of the sufferer is impaired. Often children with dental caries have disfigured mouths, lose weight and strength and fail to grow normally. Even the mental alertness and capacity of such an individual may be distinctly lessened.

Everyone knows that there are two sets of teeth, temporary and permanent. The temporary teeth are twenty in number and small in size. About the sixth year the temporary teeth begin to drop out and by the twelfth or fourteenth year they have all been replaced by the permanent set. The permanent teeth are thirty-two in number; four incisors, two canines, four bicuspid, and six molars in each jaw. The first permanent molars appear about the sixth year and the third molars about the twelfth to sixteenth year. Occasionally the latter never appear.

The temporary teeth should be cared for. If they are allowed to decay promiscuously the child will bolt its food on account of pain. Another reason for their care is to insure the proper and healthy eruption of the permanent teeth. If the temporary teeth are allowed to decay, their roots are not absorbed in time to allow the permanent teeth to erupt and they either remain buried in the jaw or appear in an irregular line. Then too the first permanent molars come in and move forward, taking positions that belong to the bicuspid, thus crowding these

teeth out of line. The first permanent molars, as was said, come in about the sixth year, appear behind the temporary molars and are often mistaken for temporary teeth. These molars have deep grooves in their surface in which the food lodges and inasmuch as they appear in many children before the habit of cleaning the teeth has been formed, are especially liable to decay. They should be immediately filled if cavities appear in them, for without them the jaws do not grow in length as they should. Count the double teeth in the mouth of a six or seven-year-old child and if there are three of them the back one is a permanent molar.

The circumstances which favor decay of the teeth are rickets, general ill health, mouth breathing, heredity and poor nutrition. The exciting causes are neglect to keep the mouth clean, malformed and irregular teeth, eating of soft, starchy and sticky foods, insufficient chewing and neglect of careful dental supervision. Breast-fed babies are less liable to have tooth decay than bottle-fed. It is bad practice to allow children to suck continually on various objects, since this is apt to cause deformities of the jaw, irregularity and crowding of the teeth. Irregular crowded teeth are apt to decay early.

After the first set of teeth are cut at the age of about two years, children should have foods which they must bite and chew before they can swallow. Soft foods like bread and milk, mashed potatoes and gravy are only suitable for children between the ages of nine and eighteen months. Even these little ones are better off for being given a crust of bread to chew occasionally. The proper foods for a child after eighteen months of age should always contain substances which can be chewed, such as brown

bread, whole-wheat bread, crusts of white bread, fish, small pieces of meat, baked potatoes, cooked green vegetables, lettuce, cress, fresh fruits and nuts. Soft foods like bread and milk, milk pudding, porridge, soft pastry, cake, marmalade, honey, jam, chocolates and soft candy cling to the teeth and inaugurate the processes of decay. Besides this they offer no stimulation to the teeth nor exercise for the muscles of mastication. After such soft foods are eaten the mouth should be rinsed with water.

The constant eating of pastry, biscuits, chocolates and candies between meals should be discouraged. Apples, oranges and other fresh fruits are better for the teeth and general health.

The teeth should be cleaned after each meal, at least two minutes being devoted to the process. At night before going to bed the cleansing should be repeated. A curved brush with bristles longer at the end should be used. The brush should be used with an up and down motion on both sides of the teeth as well as to and fro on their crowns. Rubbing the gums need not be feared if they are not bruised. Children who are too young to use the toothbrush should be taught to rinse out their mouths with water. Every child should have competent dental supervision at intervals after the beginning of the second dentition, namely, six years of age. In later life this salutary practice should be rigorously persisted in to anticipate the occurrence of decay. A stitch in time saves nine.

In many mouths a dark hard substance called tartar collects on the teeth near the gums. This should be removed by the dentist, as it is a prolific predisposing cause of pyorrhea alveolaris (Rigg's

disease). Irregular teeth should be straightened by the orthodontist.

Care of the Bowels.—Chronic constipation is a very common condition and is accredited with the production of various disorders. The causes of constipation are varied and no attempt will be made to enumerate them all. In a large majority of cases, however, the trouble results from defective habits or mode of life, many of which can easily be remedied. Unfortunately, many persons acquire the habit of taking drugs continually for the relief of this condition and very soon find themselves in a situation where the bowels refuse to act under the normal stimulus of food, but require the continued administration of aperients, often in progressively increasing doses.

One common cause of constipation is the failure to develop regular habits of daily evacuation of the bowels at a certain time. An irregular custom is set up which leads to constipation. When this cause is operating it is best relieved by establishing a regular order, whereby an effort is made to obtain a movement at a certain time. The best time appears to be after breakfast. The habit once established repeats itself with almost clocklike regularity; day after day, month after month and even year after year. The peristaltic movements of the lower intestine recur in obedience to a regularly recurring stimulus, usually the entrance of food into the stomach after a night's fast. Another common cause of constipation is a diet of food of high digestibility leaving little residue to be evacuated. The fecal mass must be of sufficient bulk in order to stimulate the intestine to contract. On arriving at the rectum the feces are small, dry and hard and

passed with difficulty. The rational remedy for this form of constipation is a change of food. Foods should be eaten containing more indigestible matter, more cellulose (woody fiber). Cooked vegetables, fruit salads and raw fruits, whole meal bread and bran should be added to the diet for these reasons.

Finally, a sedentary life with deficient exercise, leading to loss of tone in the muscles of the body generally and the intestine in particular, is a prolific source of constipation.

Exercise is consequently a natural antidote to constipation as it is in fact to sickness in general. The exercises that are best adapted to overcome constipation are those which bring the abdominal muscles into play. All forms of running games are proper for the young. Walking, golf, horseback riding and mild tennis are proper for the person of middle age. In the aged and infirm, abdominal massage will be beneficial.

CHAPTER XIII

MANIFESTATIONS OF DISEASE; DISORDERED FUNCTIONS

IT will be necessary at this point to take up very briefly the different ways in which diseases manifest themselves in different organs and systems of the body. In previous chapters, following our historical development of the great topic of medical dogma and theory, we have described the causes of disease and how they act and the important subject of prevention of diseases, or prophylaxis. Without some understanding of the different ways in which diseases affect different organs and functions of the body, the general student cannot obtain a well-rounded conception of the subjects included in Medical Science.

This is a very great and extensive domain, since it includes the whole of clinical medicine in which is included a description of individual diseases, their symptoms, diagnosis and treatment; also a description of the physical evidences of disease in organs, or pathology. Manifestly, therefore, no adequate treatment of the manifestations of disease can be presented in this book and the following pages are only included to give the earnest reader a general, though it is hoped useful, idea of the way in which different parts of the body, such as the digestive, respiratory, circulatory, excretory, and other organs, react to the processes of disease. No attempt will be made to take up individual diseases and

give their description. The only attempt made will be to present the phenomena of altered functions in different organs, brought on by the causes of disease heretofore described. The general reader will get some idea of the great importance of the functional aspects of disease which are engaging the attention of medical men of the present time just as the anatomical changes wrought by morbid processes in various organs engaged the particular, nay, almost exclusive attention of their predecessors.

ALIMENTARY DISORDERS

Stomach.—After food has been swallowed, the greater portion remains in the stomach for a variable period of time, being held therein by a closure of the lower and upper openings which are guided by rings of muscle. At first the food is acted upon by a starch changing ferment in the saliva or spittle, that is mixed with the food. After a certain period, the digestion of food by the stomach, so-called gastric digestion, begins. It has already been explained that all of our foodstuffs consist of water, inorganic salts, proteins or albumins, fats and starch-sugars or carbohydrates. Of all of these classes of foodstuffs none are acted on chemically in the stomach but the protein. Gastric or stomach digestion is carried on by means of a juice secreted by cells in the mucous membrane of the upper part or fundus of the stomach. Recent physiologists, particularly the Russian Pavloff, have shown the important part played by nervous influences in stimulating the flow of gastric juice. Thus we have a physiological basis for the commonly accepted belief founded upon general human experience that digestion is favored by agreeable surroundings at

table and by appetizing odors and tastes. There is, in other words, a powerful psychic element in the starting of the digestive processes.

The second stimulus of gastric juice occurs after the food has entered the stomach and remained there for awhile. Substances are formed usually at the lower end of the stomach (pylorus) which are absorbed into the blood and later stimulate the cells in the upper part of the stomach (or fundus) to secrete their acid digestive fluid. These substances, the exact nature of which are unknown, are called by Bayliss, their discoverer, hormones. Well-flavored and tasty soups or broths have from time immemorial, as it were, constituted the first course of a heavy meal. Their food value from the standpoint of sustenance is small, and yet they are extremely useful adjuncts to a meal when it is recalled that from their pleasant taste and smell they stimulate the psychic or primary secretion and after they have entered the stomach the meat extracts contained in the soup are absorbed and provide the second or chemical stimulating substance, the hormone. For the very same reason that soup may be so valuable as a food adjunct under normal circumstances, it may be harmful in cases where the acid gastric juice is secreted in too great abundance.

The most important constituents of gastric juice are hydrochloric acid and pepsin. Naturally, the gastric juice is sour, as anyone can testify who has vomited the contents of the stomach at the height of digestion. There is also present a rennetlike substance which clots milk. Simultaneously with the secretion of gastric juice the stomach begins to churn by so-called peristaltic movements of a special kind. Now in man the stomach normally has



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WALTER REED

a J or fishhook form and lies mostly to the left of the middle line, its lower border on a level with the navel. It divides itself, by contractions of its walls, substantially into two portions, the upper sac (cardiac sac) and the lower sac (pyloric sac). The upper sac receives the food like the first stomach of a cow and simply holds it under tonic or light pressure without much churning movement. The lower half or pyloric tube is the seat of marked churning or grinding activity. Waves arise at the junction of the two parts at the rate of three to the minute and pass down to the lower end of the stomach. Finally from time to time a portion of the contents in the lower part is allowed to pass through the pylorus into the intestine. The cardiac or upper end then delivers new material into the lower part for the latter to "churn or chew."

It will be seen from this that we have especially two main categories of gastric (stomach) activity to consider, in relation to the disturbances from which this organ may suffer. The first will relate to disturbances connected with gastric secretion and the second to disturbances of movement or motility. This is a partial view of stomach pathology (disease) from a so-called functional view. It is by no means the entire subject, but constitutes a large part of it. For in by far the larger number of cases of stomach disorder, the disturbance lies with either the secretory or motor functions.

Although the gastric juice is extremely important, it is not absolutely necessary to life, for a person need not die even though he has no gastric juice at all. The intestines are still on duty as it were to make up for the deficiency. From a quantitative standpoint there are two main pos-

sibilities; one is an excess, the other is a deficient secretion of the gastric juice. The first is called hypersecretion or hyperacidity, the second hyposecretion or hypoacidity. In hyperacidity the gastric juice contains too much acid. In such cases there are usually symptoms such as feelings of distress in the stomach, definite pain in the stomach, burning sensations in the stomach or its neighborhood and perhaps sour eructations or risings, all of which signs are most marked at the height of digestion, that is, between one and three hours after a meal. They are usually relieved by alkalies such as bicarbonate of soda or magnesia which serve to neutralize the excess of acid in the stomach. The diagnosis of hyperacidity is made definitely by removing some of the stomach contents at the end of an hour after a test meal, by means of a rubber tube, and subjecting the same to a chemical examination.

Hyperacidity is usually associated with some delay in the normal emptying of the stomach into the small intestine. Hyperacidity more than any other gastric disorder is apt to be accompanied by no manifest lesions (changes) of the mucous membrane lining of the stomach. Such a "functional" hyperacidity is particularly frequent in young individuals and in those of nervous temperament or subjected to nervous strain, care and worry. Hyperacidity may originate "reflexly," as it is called, that is, through the nervous system or from diseases or disorders in other organs; such for example as chronic appendicitis, gallstones, and constipation. Other types of hyperacidity are brought on by irritations of the mucous membrane of the stomach, as from coarse food, tobacco, alcohol in excess. In ulcer of the stomach it is a common accompaniment.

Lack of acidity of the gastric juice or hypoacidity may also be due to nervous causes or to severe organic diseases. This condition, like the preceding, is only scientifically demonstrated by means of the stomach tube. Diminution or absence of acidity of the gastric juice is frequently associated, contrary to what was said of hyperacidity, with a rapid emptying of the stomach or, as it is called, a hypermotility. The symptoms of hypoacidity are indefinite and the conditions may be discovered when the stomach is "pumped." In other cases there may be symptoms such as loss of appetite, distress after meals, and eructations (belchings). The exact causes of hypoacidity are not thoroughly understood. Nervous influences are supposed to play a part, also certain not well understood changes in the mucous membrane of the stomach. Pernicious anemia, cancer of the stomach and chronic gastritis (catarrh) may be and often are accompanied by subacidity or anacidity of the gastric juice.

In respect to gastric motility or movements of the stomach, something has already been said. The stomach muscle possesses tone or firmness, churning motions or peristalsis and control over the opening and closing of its lower end opening, namely, the pylorus. As with secretions, so with motility, there may be excess or diminution, namely, hyper and hypomotility. It has been mentioned that hyperacid states are apt to be associated with hypomotility and hypoacid states with hypermotility. Gastric atony is a technical phrase to indicate a lack of tone of the muscular wall of the stomach. It may be caused by weakening of the muscle primarily or to obstruction to the outflow from the stomach due to contraction (stenosis) of the pylorus. Pyloric

obstructions are due to actual anatomical changes or to spasmodic contractions. To the former class belong cancer, ulcer, scars, adhesions, etc., which actually tend to block the passage. To the latter, as the name implies, belong all contractions which are functional, that is, not dependent on organic change. For instance, an excessively acid gastric juice will cause the pylorus to spasmodically contract. Certain drugs like morphine have the same effect. Obstruction at the lower end of the stomach is bound to cause delay in the emptying of its contents; as the obstruction progresses it becomes more and more difficult for the stomach to empty itself with its usual speed. Pumping the stomach and X-ray examinations will disclose the existence of this fact. When pyloric obstruction to any considerable extent exists, there will be increased movements or peristalsis of the stomach which may be visible as waves or contractions through the abdomen. Sooner or later the stomach becomes dilated. So long as the muscle is able to empty the stomach, there may be no symptoms except nervous symptoms and some distress after eating. Eventually, however, the patient will begin to vomit, at first only small quantities, but later there may be large quantities raised, even three to four quarts in extreme cases. In the vomited matter there may be remains of food eaten two or three meals before, or even days before. The patient of course loses strength. Such a condition will require medical attention and the cause of the obstruction must be ascertained. There is a rather rare and remarkable form of acute dilatation of the stomach which occurs after surgical operations, particularly abdominal operations, less commonly during the course of

infectious diseases, particularly pneumonia, or from injuries, wasting maladies, and nerve diseases. It is characterized by acute onset of persistent vomiting, pain, distention and tenderness. There is great thirst and collapse and may be death. The stomach is found enormously dilated and even the upper part of the small intestine for a few inches may be similarly affected. There is loss of tone in the muscles in this kind of dilatation and consequently a diminution of the peristaltic movement. There is also an obstruction in the small intestine some inches below the lower end of the stomach and these two features, loss of tone and upper intestinal obstruction, are the two chief characteristics of the condition, although which is cause and which is effect is not absolutely known.

Intestine.—When the contents of the stomach pass into the upper small intestine (duodenum) a flow of pancreatic juice and bile is excited. The outpouring of these secretions is due to the action of the hydrochloric acid in the stomach mixture and to fat upon the mucous membrane of the intestine. It was discovered recently by Bayliss and Starling that a chemical substance called secretin is formed in the mucous membrane of the upper intestine as a result of contact of the stomach mixture, which is absorbed into the blood and being carried to the pancreas and liver excite these organs to produce their characteristic secretions, namely, pancreatic juice and bile.

At the same time that the acid contents pass the pylorus in certain amounts, a reflex is set up which closes the pylorus so that only a limited amount of stomach contents (chyme) can be delivered into the intestine at a time. The pancreatic juice and bile

are alkaline in their reaction and they thus tend to neutralize the acid chyme. When the neutralization is complete the pylorus relaxes and lets more chyme through into the bowel. The main digestion of food takes place in the small intestine. The pancreatic juice provides powerful ferments; one, which digests starch, called amylase, another, which digests fats, called lipase, and a third called trypsin, which digest albumins or proteins. The first will digest bread, the second butter, and the third meat. These ferments are first secreted in a perfectly inactive form and are rendered active by a juice secreted by the mucous membrane of the upper intestine. This activating substance in the intestinal juice is called enterokinase. The trypsin of the pancreatic juice, while less active than the pepsin of the gastric juice with regard to a few proteins, particularly those of connective tissue (tendons, gristle, etc.), is in general a more powerful ferment than pepsin and is able to carry the digestion of proteins to a more advanced stage. The final stage of this digestion is accomplished by the intestinal juice. Pepsin begins the digestion of proteins, pancreatic juice continues, and intestinal juice completes it. Not only is the small intestine the main seat of digestion, but also the principal seat of absorption. Food requires from three to six hours to pass through the small bowel, nevertheless the protein and starches are digested and absorbed.

What is left over unabsorbed passes into the large intestine through what is known as the ileocecal valve. This material is a thin juice, containing little or no nutrient matter. Progress through the large bowel is much slower than through the small, the water being gradually absorbed, the material be-

coming eventually converted into feces. In the large bowel there is an enormous increase in the number of germs. These germs are not detrimental as a rule and some of them actively assist in the digestion of some substances which cannot be attacked above (as woody fiber; cellulose).

Intestinal movements in intact animals were at first completely studied by Cannon, who examined the abdomen with X-ray. He found normally two types of movements. The first of these Cannon called "rhythmic segmentation," meaning merely that the intestine contracts simultaneously in a number of separate places, followed by relaxation of these and contraction in a number of other places, making an appearance which might be compared to the keys of a piano when chords are struck in succession. While the intestine is undergoing this rhythmic segment contraction, the contents of the bowel are not moved along, but are churned and mixed in such manner as to give the digestive juices an opportunity to become thoroughly mixed with the chyme which has come down from the stomach. The movement also aids in the circulation of blood and lymph in the bowel and thus facilitates the process of absorption. A second type of intestinal movement is that known as peristalsis. This is characterized by an advancing wave of constriction, preceded by a wave of relaxation. As a result of this combined movement, the contents of the bowel are swept along. Peristaltic motion in the small intestine proceeds at a slow rate, being estimated to be less than one-fifth of an inch per second, the wave traveling only a limited distance, about four or five inches. The length of time required for the remains of a meal to reach the large intestine is between three and four

hours and all the remains are emptied in eight or nine hours. In the large intestine the contents become less fluid on account of absorption of the water and gradually the feces are formed, the consistency of which is familiar to all in their evacuated state.

In the first part of the large intestine, that portion known as the ascending colon, the contents are relatively liquid and by a movement backward of this part of the bowel, an antiperistalsis, the too rapid passage of material is prevented, until most of the water and even slight nutrient material which they contain has been absorbed. It is not entirely agreed whether the intestinal contents pass through the rest of the colon with quick sudden movements recurring at long intervals or as a result of slow peristalsis. Quick movements are known to occur during movements of the bowel and after a meal. The time consumed for passage of contents through the large intestine is about twenty hours.

Defecation is the act of emptying the lower bowel and rectum. Chronic constipation is the name given to the slow passage of material through the intestines, particularly the large intestine. While an infrequent evacuation of feces is evidence of chronic constipation, a frequent evacuation is not evidence of its absence, because certain persons have daily evacuation and yet material accumulates in their large intestines. Indeed diarrhea may be set up by this very accumulation without securing its evacuation. Constipation is one of the most frequent morbid states with which mortals are afflicted and its results are sometimes deplorable. The passage of material through the intestines is brought about by the motions above described; and these are originated and governed by certain stimuli which act upon

the intestinal wall. These stimuli may be of a chemical or of a mechanical nature. The chemical stimuli are derived from the food. If too little is eaten there will be constipation from lack of residue. Some individuals actually appear to digest their ordinary meals so completely, there is a lack of residue from undue or over digestion. Constipation is often associated with excess of acidity of the stomach juice. Displacement downwards of the intestines (enteroptosis) may also induce constipation. It will be readily understood that a diminution in the contractile force of the bowel, atonic state as it is called, will produce constipation. X-ray studies in these patients have shown many diverse conditions which cannot be detailed here.

The Liver.—No organ of the body besides the brain possesses such a variety of functions as the liver. All the material which enters the blood from the digestive organs passes through this organ. In its passage through the liver this blood undergoes many important modifications. Toxic substances are rendered harmless. Salts of ammonia are converted into the substance called urea which escapes from the kidney. One of the most important functions of the liver is to remove excess sugar from the blood and store the same as animal starch or glycogen to be given back to the blood as needed. The liver is one site of important changes in the metabolism of albumin foods (proteins). Finally the liver secretes bile, which has an important part to play in intestinal digestion. The bile contains coloring matter (pigments), salts, and fatty substances. The bile pigments come from disintegration of the red blood cells. The bile salts are reabsorbed from the intestines and are carried

back to the liver, where they act as natural stimulants. About a pint to a pint and a half of bile is secreted by the liver in twenty-four hours.

Judging from the popular notion, liver trouble is very common, for many persons are apt to attribute almost every functional disturbance to disease of this organ. The term "biliousness" has come to be a common explanation for a variety of different states and remedies to stimulate or act upon the liver are the favorite means employed by many people to "jog" the individual who is a little "below par" back to health. In truth, the symptoms which have by common consent received the picturesque rubric of biliousness are in reality usually due to other causes, especially to constipation.

Pancreas.—The pancreas or sweetbread is a gland situated behind the stomach and is a very important organ. It has two important functions. One is the manufacture of a powerful digestive juice which flows into the upper intestine. The other is the so-called internal secretion which finds its way into the blood stream. If the pancreas is entirely destroyed by disease or artificially removed, the body tissues lose their power of burning sugar, which they are normally able to do for the production of heat and energy, and sugar accumulates in the blood and passes out in the urine. A condition of diabetes is established. In animal experiments it has been found that if only a very small portion of the organ is allowed to remain and the rest excised, diabetes does not occur. If for any reason the pancreatic digestive juice is excluded from the intestines, a marked disturbance in the digestion of fats and a lesser effect upon the digestion of starches and meat foods (proteins) takes place.

HEART AND CIRCULATION

The blood is the great transporting medium of the body. In it the life-giving oxygen is carried from the lungs to the tissues and the waste product, carbon dioxide, is carried from the tissues to the lungs. Into this wonderful fluid all the nutrient material absorbed from the organs of digestion finds its way, to be carried to all parts of the body. Waste products from every cell of the many millions which compose the organism are emptied into the blood stream and carried thence to the organs which are concerned in their excretion. Finally the blood takes up the wonderful bodies known as hormones from the organs of internal secretion, and carries these mysterious messengers on their journey from the place of their elaboration to the often far distant situations where they are to exert their beneficent effects.

In order to perform all these functions, the blood is kept in a constant movement or circulation as it is called through all the various organs and tissues. This is accomplished by the heart and blood vessels, which taken together are spoken of as the cardiovascular system. The heart muscle responds normally to an increase in its work by getting larger or thicker just as a voluntary muscle grows as the result of systematic exercise. This enlargement of the heart as the result of increase in the muscular bulk is called hypertrophy. When the heart muscle hypertrophies as a result of increased work, its strength is greater than before and it can accomplish more work and overcome a greater resistance in the circulation than it previously could. Intermittent violent exercise in a normal individual if kept up for any considerable period will always produce

hypertrophy. All animals which are called upon for violent exercise have relatively large hearts; birds, rabbits, hunting dogs, and deer, are examples.

The heart, being in reality a living pump, is provided with valves whose function is to keep the flow of blood steadily onward in one direction. Everyone has been taught at some period in his school life some rudiments of the anatomy of the heart. It is generally well understood, for example, that the heart has four chambers and that its openings are protected by valves. When any of the valves leak for any reason, the valve is said to be insufficient or incompetent and the rush backward of blood through the leaky valve is called a regurgitation. On the other hand, if the valve opening becomes narrow or contracted we call the condition "stenosis." The usual cause of a valvular heart disease is chronic inflammation of the lining membrane of the heart (endocarditis) which thickens, puckers, contracts, or deforms the valves. An individual may have a valvular heart disease and be entirely unaware of it. This is because the heart has been able gradually and silently to overcome the mechanical effects of the lesions. Under such circumstances the heart is said to have compensated the lesion. The increased work which the heart is called upon to perform to overcome the mechanical defects brought about by valvular disease causes the heart to hypertrophy and thus to become stronger and it is this increase in its strength which brings about compensation. The individual is thereby enabled to carry on the ordinary affairs of his life without being disabled, even oblivious that he has any heart disease at all. But even though compensation be good and the normal quantity of blood

be supplied to the body, nevertheless the compensated circulation is not a normal circulation for the reason that it is likely to fail when added stress comes to the possessor of it. This is called heart failure. The treatment of heart failure consists of absolute rest in bed and the scientific use of digitalis under medical supervision. Under certain circumstances which it will be impossible here to describe, this régime will bring about an almost miraculous restoration. Unfortunately, in most cases there comes a day when even the most skillful assistance will be unavailing and the patient will succumb.

Disturbances of the rate (rapidity) and rhythm (regularity) of the heartbeat have been much studied in recent years since the advent of certain instruments of precision which have enabled the observer to take graphic tracings of the movements of the heart and blood vessels and thus to analyze their character. Even complicated electric instruments have been devised by which the faintest movement of the heart can be recorded. Out of these studies has come a much more adequate conception of the fundamental properties of the heart muscle. The anatomy and physiology of the heart is now much better understood. It is known, for instance, that the heart muscle is not entirely a homogeneous contractile tissue; that contained within the masses of fibers whose functions it is to contract, there is also a type of muscle tissue differentiated from the rest whose function is not contraction at all, but impulse formation and conduction. It was formerly believed that the movements of the heart were governed entirely by nerves which entered the organ. It is now known that while these nerves do serve to regulate to a certain extent the rate and character of

these movements, they are subsidiary to the heart muscle itself, which possesses within it certain fundamental properties which initiate, preside over and regulate the discharge of its functions.

The average heart rate in a healthy grown person is about 70 beats per minute in men, and about 80 in women. In the newborn child the rate is about 130. It diminishes considerably in early infancy and to a lesser degree during childhood and adolescence. The normal adult varies considerably in pulse rate. Some persons have normally a pulse of 50 to 60, whereas others have a rate of 90 without necessarily indicating disease. The rate is easily increased in some persons by emotional causes. After exercise the pulse rate increases very promptly. When the heart is weakened by disease of the muscle the rate is frequently more rapid. An increase in the heart rate usually accompanies fever from any cause.

The Blood Vessels.—The vessels through which the blood circulates are of three classes, arteries, veins, and capillaries. The arteries begin at the heart with the great vessel called the aorta and carry the blood to all parts of the body, dividing into progressively smaller branches until they reach the right heart by two big veins called the vena cava. The pressure of the blood within the arteries is called the arterial pressure or, commonly, the blood pressure. It depends upon several factors, among which are the force of the heartbeat, the number of beats, the thickness of the blood vessel wall and the size or diameter of the vessels.

The subject of high blood pressure is much discussed in all quarters at the present time and the phrase "hardening of the arteries" is upon every-

one's lips; consequently a few words upon blood pressure will not be uninteresting. One of the most common pathological disturbances after the age of forty is a continued increase in the blood pressure. The fundamental cause of this is still somewhat obscure, but the immediate cause is to be found in an increased resistance to the escape of blood from the arteries. There is a more or less frequent connection between chronic high blood pressure and disease of the kidney, but they are not related as cause and effect in every case, for not all cases of the former are associated with the latter. Sclerotic (hardened) arteries are more or less rigid, not elastic tubes, and consequently more force is needed to pump the blood through them. Therefore practically every person who suffers from chronic hypertension has hypertrophy or thickening of the heart muscle. When the hardening process affects the vessels of the brain there may be apoplexy and paralysis, and when the kidneys are the seat of this process, a type of Bright's disease ensues. The causes of abnormal degrees of arteriosclerosis or hardening of the arteries are usually set down as heredity, excessive wear and tear, and poisons. Some persons appear to be born as Osler has said with inferior "rubber" in their vessels. Since the whole body depends so much on the condition of the blood vessels there is truth in the adage that "a man is as old as his arteries." Some people at forty have arteries as old as others at seventy, and some persons even at twenty develop arteriosclerosis and before they are thirty show the physical signs of this condition. Persons who do especially hard muscular work often have arteriosclerosis. Also those who eat too much and those who worry.

Certain poisons such as lead or alcohol in great excess and those derived from certain infectious diseases may produce it.

Sometimes the blood pressure is temporarily or permanently below the normal. This is known as hypotension. In fainting, hemorrhage, and in shock there is a temporary hypotension and the chronic variety is found in various weakening or wasting diseases, notably tuberculosis. There are other varieties which need not be mentioned. Occasionally the coat of a blood vessel will become diseased and the blood will clot at this point until gradually a mass is formed of sufficient size to obstruct the vessel. The formation of such a clot is called thrombosis and the plug itself a thrombus. If such a clot becomes loosened and washed away by the blood stream, it is called an embolus and such a foreign body may be carried to a distant part of the body and there become finally lodged in a vessel too narrow to admit its passage. Apoplexy may occur in this manner from an embolus washed away from a heart valve. Finally it may be mentioned that the wall of a blood vessel may become weakened through disease and owing to pressure from within, may bulge out like a blister on a tire, forming what is known as an aneurism. Just as a blister on the tire may bulge and finally "blow out," so an aneurismal tumor may eventually weaken and rupture, usually producing the death of the unfortunate individual affected.

The Blood.—The functions of this important fluid have already been cursorily mentioned and but little space can be devoted to their elaboration. Nor can we in these pages enter upon the interesting subject of the composition and physiology of the blood.

There are about five quarts of blood in the circulatory system of an adult person. Round and round it goes upon its continuously beneficent errand from a period long before our entrance to the world until the moment of death. As long as all is well the blood is strictly fluid. Let it escape from the vessels in which it is normally contained and a wonderful change takes place; it clots.

The term anemia, though meaning a lack of blood, has come to be applied to those conditions in which the number of red cells or the amount of their coloring matter (hemoglobin) has been reduced. Patients who are anemic usually look pale, but pallor of the skin is not necessarily due to anemia. Certain persons habitually have a pale skin, although an examination of their blood shows no deficit in hemoglobin. The combination of hard work, poor food, and dark dwellings often produces pallor which may or may not be associated with anemia. Anemia can only be definitely recognized by an examination of the blood. Anemias are primary or secondary. By secondary anemia is meant an impoverished blood from some known cause, as hemorrhage, infection, deficient food or poisons. Hookworm anemia is an interesting type of secondary anemia which has been much studied in the United States in recent years by experts working under the Rockefeller Foundation. By primary anemia, is meant an anemia whose cause is unknown.

Much is being written and spoken at the present time about transfusion of blood. The possible advantages that might accrue from the transfer of blood from a well person to a sick one have long been recognized, but it is only recently that mechanical and other perfections of technique have been

developed and brought the procedure into far greater vogue. One danger in transfusion of blood which has long been recognized is that the blood serum of one person may destroy or hemolyze as we say the red cells of another. A clumping or as it is called an agglutination of the cells is more common than hemolysis. Moss has classified all individuals according to the clumping power of their sera and the behavior of their red cells into four different groups, and within each group no disturbance occurs when the blood of different individuals belonging to the group are mixed. This allows transfusion to be safely done and it only becomes necessary in a given case where transfusion is to be attempted to find in which group his blood belongs and to select a "donor" or giver of blood belonging to the same class. In certain anemias, poisoning from illuminating gas, and in hemorrhages, the transfusion of blood has given good results. It has come to be such a fad, however, that it is done in many conditions and under many circumstances where no results of a beneficial character are obtained.

DISORDERS OF RESPIRATORY OR BREATHING ORGANS

Respiration includes all those processes whereby the oxygen of the air is carried to the tissues and carbon dioxide is taken from them and returned to the air. All the living cells of the body require oxygen in the same way and for the same purpose that a stove requires it—namely, combustion. The ashes produced by the human body as a result of burning up of some cellular and food materials is carbon dioxide. The oxygen is carried to the cells of the body by the red corpuscles of the blood; each

one taking up its tiny portion as it passes through the lungs and carrying it on to the outmost confines of the body. This transplantation of oxygen to the cells and carbon dioxide away from them is called "internal respiration." The act of breathing air in and out of the lungs is called "external respiration."

External respiration or breathing is effected by increasing and diminishing the size of the chest. The lungs, being elastic, follow these movements and air flows in and out of them through the air passages. The total quantity of air which can be made to leave the lungs when a maximum inspiration is followed by a maximum expiration is called the vital capacity. This can be measured by a special instrument called a spirometer. The movements of breathing are controlled by a nerve center lying at the base of the brain in the medulla oblongata. This center is influenced by stimuli which come to it by way of the nerve paths and also by way of the blood. The slightest increase in the carbon dioxide content in the blood makes the respiration faster and thus increases the ventilation in the lungs. If on the other hand, the amount of carbon dioxide in the blood is diminished, as by forced respiration, the breathing slows or stops until the normal quantity (tension) of carbon dioxide is restored in the blood. Carbon dioxide acts in the blood like an acid and reduces its alkalinity.

In normal individuals the respirations are fairly regular. Of course they are to a certain extent under the control of the will. Deep gasping breaths are often seen in hysterical patients and changes of respiration are produced by emotion. There is a type of irregular respiration of great interest and importance from a medical standpoint known as

Cheyne-Stokes respiration, so called from the observers who first described it. It is also called periodic breathing. In this condition, there is a more or less regular alternation of periods of stoppage of breathing, with periods of deep or difficult breathing. In marked cases the period of absence of breathing is accompanied by drowsiness, the eyes close, and the head drops forward. During the period of deep or difficult breathing the patient awakens from his drowsy stupor, the head is thrown back, and all the muscles of respiration are strained in the effort to get breath. Periodic breathing is most apt to occur during sleep. It seems common in infants as a more or less normal phenomenon. Sleeping at high altitudes usually brings it on. Clinically, that is medically, Cheyne-Stokes respiration is observed in diseases of the heart, kidney, and brain. It is not infrequently encountered in cases of hardening of the arteries (arteriosclerosis) and chronic increase of the blood pressure (hypertension). Cheyne-Stokes breathing is due principally to deficient oxygen supplied to the respiratory center of the brain.

It is a striking and well-known fact that one of the most important symptoms of heart failure is shortness of breath. The shortness of breath of heart failure is closely associated with exertion. In the milder types it may occur occasionally after rather severe exercise, but in severer cases it is present constantly and is increased by the slightest exertion. It is much affected by position, for patients often breathe better when they are sitting up than when they are lying down. In heart failure accompanied by hardening of the arteries, or Bright's disease, the shortness of breath may occur in par-

oxysms particularly during the night; so-called heart asthma. The shortness of breath of heart failure is often associated with a damming of blood (congestion) in the lungs, so that an insufficient ventilation of the air in the chest results from lack of lung movement. The congestion also interferes with the interchange of gases between the blood and air in the lungs.

The Nose.—The air on entering the nostrils does not go straight backward, but passes upward to the roof of the nose and it is then deflected downward into the windpipe. This is due to the pressure of little shell-like bones called turbinates, three in number, on each side, covered with mucous membrane which somewhat obstructs the air current. The air is thus warmed and germs and dust are caught up and kept from entering the lungs. The sense of smell is located at the top of the nose. An acute catarrhal inflammation of the nose is known as "cold in the head," or coryza. It is a very common disease and there is no unanimity of opinion concerning its cause. It is generally believed to be due to infection by germs. Very often it follows changes of temperature, wetting the feet, or getting in drafts of air which strike the back. There is sneezing, running at the nose, and obstruction to breathing. The last symptom may force the sufferer to breathe through his mouth.

When a child suffers from well-marked adenoid growths in the naso-pharynx, breathing through the nose is interfered with and the child becomes a "mouth breather." In well-marked cases there is a sort of stupid expression of the face. The voice is nasal. The adenoids block the Eustachian tubes, which pass from the throat to the middle ear, and

a chronic inflammation often arises, after several acute attacks, with pain in the ears and discharge from the ear canal. Breathing through the mouth may set up chronic throat troubles. Even asthma may be set up by adenoids. The proper treatment is removal.

DISORDERS OF KIDNEY FUNCTION

The kidneys get rid of most of the ashes of the body; that is, the burnt-up products which are of no use and whose accumulation in the organism would be deleterious. The excretion passed by the kidney is called urine, and although it looks simple enough on ordinary inspection, yet is a complex fluid and contains many substances.

The chief substance which it contains is urea, which can be obtained from the urine in beautiful white crystals. About one-half of urea by weight is the element nitrogen. Nearly ninety per cent of the nitrogen eliminated from the body escapes in the urine as urea. The nitrogen comes from the breaking down of the proteins of the food and tissues of the body. Almost an ounce of urea is voided by a normal person every day and every ounce represents about three ounces of protein which has been burned. On a diet poor in meat and other protein, less urea will be passed. When the kidneys become diseased in a certain way they may become unable to satisfactorily eliminate urea.

Besides urea there is another substance containing nitrogen in the urine. This is called uric acid, a name which is familiar to most people, since there was a time not long ago when everyone seemed to assume that most of the diseases to which flesh is heir are in some way due to it.

As Emerson says: "No substance in our bodies perhaps has been the subject of quite so much romance as this acid. Forty-six different diseases have been supposed to be due to it, and the list includes gout, rheumatism, nervous disorders and even one eye trouble." It seems without doubt, however, to be increased in gout, or at any rate its formation, mobilization and elimination are very much disturbed in this disease.

Of the salts in the urine, sodium chloride, or ordinary table salt, is the most important. About fifteen grams or one-half an ounce of this substance is eliminated daily. Salts of sulphur (sulphates) and of phosphorus (phosphates) are also eliminated, about two grams per day each. Certain substances, as sugar and albumin, appear in the urine under conditions of disease.

All of the above constituents of the urine are brought to the kidney by the blood and it is the duty or function of this organ to pick out certain quantities of each and pass them into the urine.

The natural effect of this mysterious and selective eliminative power of the kidney is to keep the blood free from an excess of them; in other words, as it is expressed physiologically, to maintain proper concentration of the blood, neither too dense nor too dilute.

The secretory function of the kidney is apparently not governed directly by nerves, but principally by the composition of the blood.

Any considerable increase in the amount of urine passed is known as polyuria. It is a common observation that the amount of urine may be increased by drinking large amounts of liquid. In the normal individual this takes place promptly and after

drinking a large amount of water most of the excess is passed in the urine within a few hours. Polyuria also occurs during the disappearance of dropsy and fluid accumulations in the organs, tissues, and body cavities generally. Thus a person who is recovering from an attack of heart failure and dropsy will pass a large amount of urine as the symptoms improve and the dropsy diminishes.

Polyuria also occurs after fevers, and after the ingestion of certain drugs, especially those which are contained in coffee, tea and cocoa (caffein, theobromine). The passage of a greatly diminished amount of urine is known as oliguria, and cessation of urinary flow entirely is called anuria.

Oliguria or diminished urinary flow is due to three fundamental causes: lack of water supply, poor circulation in the kidneys and inflammation of those organs (nephritis). Lack of available water may be due to reduction of quantity of drink or to excessive sweating. Poor circulation in the kidneys may result from any cause, for example heart failure, which slows the general circulation.

In acute and in some types of chronic inflammation of the kidney, or nephritis, diminution of urinary flow will ensue for various reasons. Among these are reduction of activity or vitality of the secreting cells which line the narrow tubes in the kidney or to actual obstruction of these tubes with material which cannot pass and therefore blocks them.

The diminution of urine produced by inflammation of the kidney, and also that of heart disease, is accompanied by retention in the body of substances like water, salt and urea. It has been found that in acute inflammations of the kidney the making

of an incision into the organ through the capsule will make it secrete more urine; this it does by relieving tension. Occasionally such an operation is performed, especially in cases with dropsy and diminished output of urine. If the urinary output diminishes to zero the condition is spoken of as anuria, or suppression. Sometimes this is due to some obstruction below the kidney itself which prevents the urine from flowing, as from stone, tumors and stricture. Anuria sometimes accompanies poisoning from bichloride of mercury. After complete stoppage of urine the symptoms may be suprisingly few. As days go by the patient becomes weak; the breath is foul; there may be muscular twitchings, but only rarely convulsions. Toward the end the patient becomes drowsy and may die suddenly or after a brief coma.

Normal kidney cells will not permit albumin to pass through, consequently when this substance is found on analysis of the urine (albuminuria) something is wrong. It may not necessarily be serious and may be temporary (physiological albuminuria), but in the majority of cases it indicates inflammation of the kidney or Bright's disease. The physician always searches carefully to ascertain the cause of albuminuria when it is once discovered. Under rare circumstances the eating of large amounts of eggs may produce albuminuria. Violent exercise, such as racing, rowing, athletic contests, may also produce it. Prolonged exposure to cold may do the same. In all these cases, however, the condition is temporary and functional. Most cases of albuminuria, however, are not functional in their nature, but are due to organic disease, either of the kidneys themselves or the urinary passages. The

majority of cases are due to actual kidney disease (nephritis).

By casts in the urine is meant the presence of microscopic molds of the kidney tubes or tubules. They are visible under the microscope and always indicate, when present in sufficient numbers, inflammation of the kidney (nephritis).

Patients with chronic nephritis or Bright's disease not infrequently show a variety of disturbances which denote a general intoxication, which may even prove fatal. To these disturbances the name uremia has been given. It cannot be said that the true nature of this condition is positively understood, for it is not known whether uremia is due to the retention in the body of substances which should normally be eliminated in the urine or whether it is due to abnormal poisonous substances formed in the body as a result of perverted chemical changes (metabolism) during kidney disease.

In uremia there may or may not be an increased retention in the blood of an excess of those nitrogenous bodies which we have mentioned above. Some cases of uremia are accompanied by very marked nitrogen retention in the blood and others are not.

THE DUCTLESS GLANDS

Up to the last part of the nineteenth century it was supposed that the activities of all the organs were directed alone through nervous control. The activities of voluntary and involuntary muscles and of glands were thought to be directed exclusively by energies originating in the nervous system and transmitted through nerves to these organs. At the present time, however, it is known that the body functions are regulated, not alone by nervous in-

fluences, but also by mysterious chemical substances that pass from certain organs into the blood stream to be carried to distant parts where they exert their effects. These substances have received the name of hormones and are elaborated by organs of a glandular structure situated in different parts of the body which have long been known to anatomists, but which, having no ducts and hence no channels through which a tangible secretion could be seen to escape, remained a riddle to physiologists until very recent times.

The chief of these organs are the thyroid gland, the hypophysis and the suprarenals. The thyroid gland is situated at the front and lower part of the neck. The hypophysis or pituitary gland is situated at the base of the brain, to which it is attached by a slender stalk. The suprarenal glands are located on the upper pole of each kidney. There are other ductless glands in the body, but their description here will not be possible. The secretion from each of these glands is called an internal secretion and gains entrance to the body not through a duct but through the circulation.

Now besides the three ductless glands mentioned there are certain glands in the body which have ducts and hence external secretions, which also elaborate internal secretions just like the true ductless glands. Among the glands or organs which possess this double function may be mentioned the pancreas, liver, intestinal mucous membrane and the sex glands.

The two chief ways in which internal secretions have been demonstrated and their effects studied are, first, the finding of an active substance in the blood leaving the gland and second by observation

of the effects which result from the excision, i. e.; removal of the gland by surgical operation. To these methods may be added observation of changes induced by implanting the excised gland back into the body from which it was removed, or administering the gland or its preparations to the individual either by mouth or hypodermic injection.

All these methods of study have revealed in recent years a mass of important knowledge, but although an enormous amount of labor has been expended in the effort to resolve the mysteries of the ductless glands, it must be said that only the beginning of their exploration has been made.

Generally speaking, the function of a ductless gland when abnormal, departs from a physiological equilibrium in one of two directions; namely, by increase or by decrease of its activity or as it is called hyperfunction or hypofunction. The vastness of the whole subject and its complexity will preclude any adequate development of the subject of ductless glands and their disorders. But in order to make this fascinating branch of medical pathology clearer to the reader than it might otherwise be we shall select the thyroid gland as a type of ductless gland and briefly develop what is known of its normal function and what phenomena are induced when, through the processes of disease, its function is increased, diminished or destroyed. The thyroid gland is a ductless gland, composed of two lobes, lying on each side of the windpipe and joined in most cases by a middle lobe or isthmus which connects the two.

Our knowledge of the function of the thyroid began with the observations of Gull in 1873 and Ord in 1878 on the disease now known as myxedema

and the observation of Kocher in 1882 and Reverdin in 1883 upon the effects which followed the removal of the gland for goiter. The name myxedema was given by Ord in 1878 to a disease in which a peculiar swelling is found beneath the skin. The swelling at first suggests an ordinary edema or dropsy, but it differs from the latter in not pitting on pressure. It is due to the presence of a mucuslike substance infiltrating the tissues of the skin and its supports. The swelling is particularly noted about the cheeks, nose and eyelids. It gives the face a peculiar expressionless appearance. Swelling is also common in the neck, particularly above the collar bones and on the backs of the hands and feet. The tongue becomes enlarged, the voice hoarse. The skin is dry and sallow. The nails are brittle, the hair dry and brittle and the teeth decay. The weight increases, the temperature is subnormal and the heart is slow. Characteristic mental changes appear, the most common and striking being apathy and somnolence.

Such a condition as that above described constitutes myxedema and may gradually appear in an individual as a well-marked disease, without the intervention of any known cause. It was because Kocher, Reverdin and others noted a similar set of symptoms follow complete surgical extirpation of the thyroid gland in goiter cases that the connection between the thyroid and the symptoms came to be apparent.

Myxedema is therefore due to a diminution and annihilation of the function of the thyroid gland or hypothyroidism as it is now called. Now occasionally a child is seen in early life, showing striking resemblances to the adult with myxedema. Here

the development of bones is incomplete. The individual has the stature of a dwarf; the face is small and puffy, dentition or teething is delayed, the mental development is much retarded. Such a child is called a cretin and its cretinism is now known to be caused by hypothyroidism. In some parts of Europe cretinism is endemic as it is called, that is, confined to certain districts. All over the world, however, occasionally, cases occur in every way similar to the endemic form and these have received the name of sporadic cretinism.

A great discovery was made when it was found by Schiff and Horsley that if a piece of normal thyroid tissue is engrafted into the body of a myxedematous individual, before the mentality is irremediably destroyed, the unfortunate victim will improve. Murray soon afterward substituted the subcutaneous injection of thyroid juice. The results of this were eminently satisfactory, but it was soon found that the same results could be obtained by administration of the gland tissue by the stomach. A large number of cases are now on record where even the complete disappearance of symptoms has followed this medication. These cases include not only myxedema patients, both children and adults, but also cases in which the thyroid was removed by operation.

The administration of thyroid substance to myxedema patients causes striking changes. The swellings disappear, the skin becomes warm and soft, the mental apathy and stupor disappear. The administration of thyroid substance to sporadic cretins causes a wonderful development of their minds and bodies; a true transformation taking place. So much for hypothyroidism.

The remarkable improvements which followed the administration of thyroid preparations to cases of hypothyroidism led to further studies. It was found that excessive feeding of the gland might lead to the occurrence of toxic symptoms in certain cases; such as loss of weight, hot sensations, sweating, rapid pulse, trembling, restlessness, sleeplessness and digestive disturbances. Now these symptoms are very similar to those found in a disease known for many years and called Graves' disease, which was recognized in 1886 by Möbius as due to increased activity of the thyroid gland. It is here proper to state that the thyroid gland elaborates a secretion which contains iodine, intimately bound up with a complex albumin called thyreoglobulin. Upon this substance its activity depends. The presence of the internal secretion of the thyroid gland is absolutely necessary for the maintenance of health. Its absence brings on myxedema. Its excess produces toxic symptoms.

Graves' disease is also called exophthalmic goiter because it is accompanied by an enlargement of the thyroid gland or goiter and by prominence of the eyeballs (exophthalmos). Other symptoms are tremor, rapid heart action, loss of flesh and sweating, etc. The similarity of these symptoms to those produced by administration of excessive amounts of thyroid gland or goiter and by prominence of the matter of fact the symptom-complex, as it is called, of Graves' disease is due to this excessive and abnormal functional activity of the thyroid gland. A fundamental disturbance in Graves' disease is a great increase in the rate of combustion of the tissues. This produces the emaciation which occurs despite a large intake of food. The disease some-

times follows fright or unusual excitement or emotion, at other times comes on insidiously. We can not enter further into a consideration of this interesting though terrible disease. Knowing that it is due to or at least invariably accompanied by increased activity of the function of the thyroid, efforts of treatment are all directed toward diminishing this overactivity. We cannot discuss here the particular methods by which this is accomplished.

The other ductless glands, as the suprarenals and the hypophysis, are affected by opposite states of hyper and hypo-function.

We cannot enter into a description of these states in this volume. Enough has been said to show the reader the enormous importance of the ductless glands in maintaining the normal functions of the body and how serious are the conditions which result from any marked disturbance in their functions, whether such variation is in the nature of an excess or of a diminution or deficiency of their activity.

Closely connected anatomically and functionally with the ductless glands is that part of the nervous system to which the name Vegetative Nervous System has been given. The name Sympathetic has also been given. It consists of those nervous structures which supply impulses which govern all the automatically working organs of the body, such as the heart, lungs, intestines, blood vessels, glands, viscera, etc.

Among these automatically working organs are the ductless glands which appear in many instances to exert their effects through the sympathetic nervous system. When one considers how many of his bodily



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functions are carried on without the intervention and often quite without the control of his volition, he begins to appreciate the tremendous importance of the sympathetic nervous system which correlates all these activities.

Now the activities of all the ductless glands are correlated, that is, brought under orderly control, by the vegetative nervous system. All of the automatic organs of the body such as the heart are more or less constantly in action and when normal, perform their function without our knowledge. Their disturbances are reflected into the central nervous system by way of the nerve fibers which belong to the vegetative system. Such disturbances when they reach a certain point produce sufficient irritation to enable them to push beyond their natural limitations and rise into consciousness. The ordinary processes of normal digestion are unfelt. The processes of abnormal digestion may obtrude themselves as disagreeable feelings or effects which may vary from mild discomfort to the most exquisite pain. Oppositely, conditions of the mind, particularly the emotions, are reflected into the vegetative nervous system and from thence to almost any domain of the body.

In many nervous conditions as in the neuroses or mental-nerve diseases we see symptoms referable to the participation of the sympathetic nervous system in the primary mental disorder. Thus we see palpitation of the heart, loss of appetite, fainting, crying, diarrhea, sweating, dilatation of the pupil, blushing, goose flesh, rapid pulse, dryness of the mouth, etc., all brought on by psychic (mental) states through the sympathetic nervous system.

MIND AND ITS RELATION TO DISEASES

In the consideration of the mind and its influence upon disease, we must not lose sight of the individual as a biological unit and of the fact that the nervous system partakes of the unity of the whole. For a long time, the interest of the medical profession was centered upon diseases in which there were actual tissue changes; mental and nervous diseases were forgotten; the mental side of the human being was neglected or at best looked upon as a factor independent of medical consideration. While men are structurally not essentially different and mentally too do not differ much from their remote progenitors, whose environment was more nearly that of the lower animals, the artificial features and complexities that have arisen in our daily life tend to make the surroundings of man more and more different from those in which he evolved and for which his body and mind are really best suited. Life has to-day become much more complex; it exacts more of us, more of our cerebral activity; it lays bare our weaknesses. On the other hand we have become more tender and more interested in our ills, and modern medicine regards the well-being of each of us with more solicitude than ever before. Through the new science of mental hygiene we are constantly reminded that the mind and its functions are closely related to and influenced by the environment. How often have we noticed the depressing effect upon the sick when they are in ill-lighted and dreary rooms, and the stimulating effect upon the convalescent of his removal from the hospital to his home. The psychic (mental) disturbances of the human body have been considered only as individual equivalents

until recent years, but now such unfortunate members of society have become of common interest to the community, and their welfare of far greater importance.

In health (soundness of mind) the mind is made up of normal beliefs or groups of associated ideas relating to certain events or experiences of life and bound together by "feeling." If in the constellation of these ideas there are some which are associated with painful experiences, they are repressed into the so-called subconscious mind and cease to be under control of the direct will or conscious mind, and which may sooner or later force their expression over the conscious mind. This repressing or crowding painful emotional states out of clear mind, thus allowing their independent existence and their manifestation in the form of symptoms, is called a "complex." A normal complex is one in which there is a group of associated ideas relative to a given subject. An abnormal complex may be said to be a group of ideas not associated with other idea groups within the mental make-up of the individual. This dissociation is readily seen in the demented individual who believes in his royal birth, despite his actual station in life. A normal complex would be where an idea occurs to the mind to take an unfair advantage of one's father. Immediately there is a "conflict" of this idea with other associated ideas based upon affection, love, loyalty, etc. The conflict (reasoning "pro" and "con") may be quite severe but this in the normal process is thought out and definitely settled, whereas in certain abnormal individuals, the feeling caused by even the entertaining of such thoughts toward one so loved will cause a reaction and the idea is repressed or so to

speaking "put out of mind." However, this is not the end of the problem, as the idea being only repressed is not disposed of and tends to seek expression later in some new and unrecognized form. The continued repression of sexual impulses may lead to false modesty—to distortion of the maternal instinct with transformation of affection upon animals or other pets.

Psychiatry* is the stepchild of medicine. All the other branches of medicine have one great advantage over it—in that the scientific methods can be more readily applied; there are things to be seen, and felt, physical and chemical methods of investigation to be followed; the microscope shows the dreaded bacillus, the surgeon's knife halts at no difficulty and gives us glimpses of most inaccessible organs of vital importance. Psychiatry which engages in the exploration of the mind stands ever at the door seeking in vain to weigh and measure as in the other departments of science. We have long known that we have to do with a definite organ—the brain—but only beyond the brain, beyond the morphological basis do we reach what is important to us—the mind—as indefinite as it ever was, still eluding any explanation, no matter how ingenious.

The position of insanity, both as regards the community and the profession of medicine, has been peculiar. It was looked upon as something apart from medicine and until recent times was the subject of religious and superstitious interpretation. The Hebrews, Egyptians and early Greeks considered the insane as persons dominated by evil spirits, victims of demoniacal possession or the servants of the Deity. The superstition pertaining to the

* Mental medicine; study of mental disorders.

mystic behavior of the demented was somewhat lifted and superseded by quasi scientific explanations in the rise of later Greek, Alexandrian, and Roman civilizations. During the advent of the Christian era (second and third century) there was a repression of the scientific conceptions as to the nature of insanity and theories of witchcraft and sorcery again prevailed, resulting in a woeful neglect of the insane. They were often cast into dungeons, clothed in rags, confined in chains, and even driven from the cities. This treatment may be said to have continued after the dawn of the renaissance. Little by little physicians began to reason in a philosophical and metaphysical way and psychological explanations began to take the place of religious theories. Until within recent years the results of scientific progress in psychiatry have been of a descriptive character and picture formations rather than an interpretation of symptoms based upon certain psychological concepts of the individual reactions.

The marked development in modern psychiatry of late years may be said to be due to a methodical testing of the psychic functions and a thorough analysis of the psychic changes manifested. Insanity means an abnormal function of the mind in which there is a persistent departure from the normal manner of thinking, acting, and feeling. The symptoms of insanity are always those of disturbed cerebral action and most frequently are attended by few or no changes in the general structure of the brain tissues. In order to familiarize the reader with the symptoms presented by the insane, it is necessary that a few definitions should be given. One of the most prominent symptoms found in the mentally

sick is an hallucination which is a sensation without an object; that is to say there is a sensation which arises spontaneously in the mind without there being an object in the external world to excite the sensation. This symptom may affect any of the senses, as when a patient hears a bell ringing, when in fact there is no bell ringing. This is spoken of as an auditory hallucination. If he sees picturesque scenes or abnormal objects when they are not in the normal field of vision, it is spoken of as visual hallucinations. He may also have hallucinations of taste, smell, touch, or other obscure sensation referred to various parts of the body. Some patients present what are termed illusions. This is a perception which is misinterpreted. An illusion therefore differs from an hallucination in that there is no actual object in the external world. An impression is made upon the senses but the object is incorrectly interpreted. An example would be when a chair is seen and is mistaken for an animal; or a rag upon the floor for a snake. It must not be forgotten, however, that a mistake in perception may be due to defect of an organ such as the eye, and not of psychic origin, but these mistakes do not constitute an illusion. While this distinction between illusion and hallucination has been accepted, it is now claimed by some authorities that hallucinations may arise from some external stimuli, which, if true, destroys or nullifies the old distinction between hallucination and illusion.

Patients also present what are termed "delusions." A delusion is a false belief, but as such may not necessarily constitute insanity. There are sane and insane delusions. An insane delusion differs from a sane delusion in that it is highly improb-

able, not true to facts, and cannot be corrected by an appeal to reason. It is the inability to accept the proffered evidence of the unreality that stamps the delusion as an insane one. A man may believe that he is pursued by his enemies who are continually trying to poison him and who upon reasoning and proof to the contrary is unable to change his mental attitude and belief. Such a person is suffering from an insane delusion. Delusions are also frequently spoken of as systematized, unsystematized, expansive, or depressive. A systematized delusion is one in which there is a logical structure in the formation of the delusion; an example would be one in which a person who is suffering from a delusion of being electrocuted continually places rubber or glass under his bedposts to prevent the conduction of the current into his body while lying down. An unsystematized delusion is one in which there is an absence of such a logical structure in the delusional content. An expansive delusion embodies the idea of great wealth, power, beauty, grandeur, and other qualities of greatness in the patient. An example would be, instead of a delusion of possessing a few houses he would own villages, cities, states, countries and finally the world. A depressive delusion embodies the idea of physical or mental wretchedness, of poverty or other qualities indicative of mental suffering, such as the delusion of the unpardonable sin.

It is not intended in a book of this character to discuss the individual mental disease, but only to give the reader a view of the psychological mechanisms which tend to make up the abnormal functions of the mental and nervous individuals as we see them in the world. These functional psycho-

neuroses may be considered as early departures from the normal way of thinking, acting, and feeling and which tend to appear in a more aggravated form in the insane. One of the most important is hysteria.

Hysteria has been an interesting problem since the earliest days of medical thought. Unrecognized it occasioned the demoniacal possessions of the Middle Ages, and furnished some of the martyrs of witchcraft and religious fanaticism. Affecting whole communities it caused widespread epidemics, allayed by appeal to St. Guy, St. Vitus, or other tutelary saints. It has been seen in the excited religious gatherings of all countries. It is almost impossible to give a brief and accurate definition of hysteria because so many symptoms are included under it. It is a distinct disease and a great one, and should not be spoken of and considered lightly—a habit which is only too prevailing not only among the laity, but among medical men. The reason for this is because many of its symptoms can be removed by persuasion.

For many years considerable thought has been given to the problem of hysteria and other psycho-neuroses; the most notable workers in this field have been Charcot, Sivilis, Prince, Babinsky, Frommelt, Janet, Freud, and White. One of the most recent workers and one whose theories produced the greatest influence in the study of this disease is Doctor P. Janet of Paris. He believed hysteria to be a mental malady and his theory was a dissociation or doubling of the personality. He believed that certain groups of ideas were not effectively associated with the main portion of the personality, with the result that they existed more or less independently and produced their results irrespective of correc-

tions from the rest of the personality. He believed that these split-off or independent ideas existed in the so-called subconscious mind and that the hysterical manifestations were the expressions of these split-off parts of the personality. Sigmund Freud, a Viennese physician, attacked the problem of hysteria along interpretative psychological lines and showed that the dissociated ideas were out of harmony with the rest of the personality and that they represented ideas that were in conflict with the ideas forming the consciousness of the individual and that they were therefore "repressed" or so to speak put out of mind. Freud considered the repression as the fundamental factor at the basis of hysterical manifestations; an active mental factor which tended to put out of mind certain unacceptable groups of ideas and was therefore the cause of the dissociation. It must be remembered, however, that these split-off complexes go on functioning, but the functioning is independent, more or less, of the balance of the personality. This process of dissociation and repression following upon "conflict" (of ideas) is a general one and in fact a normal process, but it is the expression of these split-off complexes which manifest themselves that produce the different types of mental disorders.

If we consider that the individual or the psyche is the possessor of an adaptive mechanism which is always attempting to make a closer adaptation of the individual to his environment, then the meaning of a conflict is that there enters into this mechanism certain factors to which it cannot make an efficient adaptation. The mechanism, however, does not stop here, but tends to readjust these difficulties by bringing about a new state of affairs in an artificial

world which is not governed by the strict laws of cause and effect, thus allowing the opposing forces to attain a settlement of one character or another. In the different mental disorders, this readjustment is attained in different ways, so that the painful effect (feeling) of the split-off complexes is drafted off by various channels to find expressions and the patient is saved from a realization of their true nature. In hysteria, the painful effect is drafted off into bodily innervation, thus producing the somatic (body) phenomena of hysteria by a process called conversion. Most authorities regard the hysteric as infantile and believe that there are certain defects in the psychosexual development which tend to remove the individual from the actual world of reality and to center him back within himself. To resume, hysteria may be said to be the result of a splitting up of the personality in which split-off complexes, usually sexually determined and leading an independent existence, express themselves by the mechanism of conversion in bodily innervation.

The patients are abnormally irritable and slight annoyance may lead to explosive behavior. It sometimes seems as though the smallest excitation causes the greatest reactions. A single well-meant word may precipitate an attack. The hysteric may be talkative, jolly, and easily accessible one moment, and the next moment without any apparent reason become the reverse; irritable, stuporous, sullen; no one can foresee the patient's mood. Their feelings are easily hurt, they believe that they are "misunderstood," they think that others do not pay them the attention that is their due. In the so-called grave hysterical attack, the patient sinks to the floor, rarely if ever hurting himself, and may assume

and maintain abnormal postures or exhibit wild rotary and bizarre movements. All forms of functional paralyses and various disturbances in the sensation of the skin may manifest themselves, but differing from diseases in which there are organic changes in their symbolic grouping. During the recent World War such hysterical phenomena as deafness, mutism, paralysis, more especially of the left arm which was necessary to hold the gun, and loss of voice were not uncommon. The treatment of the hysteric is a large problem and demands considerable attention on the part of the physician. We no longer tie our hysterical patients to the stake; we nurse them; we do not load them with chains; we give them ample freedom; we do not leave them to themselves; we do not let them wander about as though they were abject wrecks of humanity, but we give them moral and psychic treatment.

PSYCHOANALYSIS

The subject of psychoanalysis is much in evidence and is likely to occupy still more attention in the near future as the psychological content of the neuroses and mental diseases is more generally appreciated and understood. This so-called analytical psychology has caused considerable prejudice because the conceptions of Freud, the founder of this method, laid particular stress upon the sexual element. Another prejudice which is based as a rule upon a superficial knowledge of psychoanalysis is that the method is one of suggestion by which a faith or doctrine of living is imposed upon the patient, thereby effecting a cure in the manner of mental healing. It may be stated in brief that psychoanalysis endeavors to overcome the disorders

through the subconscious and not through the conscious self, although we naturally have need of the patient's conscious content, for the subconscious can only be reached through this means. The popularity of dream analyses in the last few years can be said to be due in part to their use by the various schools of psychology. The interpretation of dreams as well as the meaning given to them is as we know in bad odor. The time is not long past when even the most enlightened human beings were entirely under the ban of superstition and it is therefore comprehensible that our age should still retain a certain lively fear of these superstitions which have but recently been overcome. To this timidity in regard to superstitions the opposition to dream analysis is in a large part due. The dream is selected because it is a psychic product, that is, independent of the patient's consciousness and because it is practically impossible to obtain his free thoughts in any other way. According to Freud, a dream is in its essence a symbolic veil for repressed desires which are in conflict with the ideal personality. We may, therefore, regard the dream from this viewpoint as a product of the subconscious and as such only can it be used as a source of material for analysis. A dream which at first sight appears to be in striking contrast with conscious thought because of its mode of genesis, is upon analysis found not to be entirely severed from the continuity of the conscious. In almost every dream certain details are found which have their origin in the impressions, thoughts, and state of mind in preceding events.

As regards the much discussed "symbolism" of dreams little can be said, as it would carry us

too far afield, but from the viewpoint of finality the various dream pictures each have their own peculiar value as an expression of an altered psychological reaction. Phantasy formations which are formed in the daytime as well as misspoken words are also of value as being indicative of certain mental processes within the individual. The technical unfolding of these subconscious expressions is a mode of procedure that has always been instinctively employed and tends for its purpose to determine the presence and nature of the dissociated ideas or complexes which are exercising a controlling influence upon the conduct and feelings of the patient. While it is true that the main avenue of approach to the understanding of these dissociated, repressed, or unconscious motives of action are through subconscious mechanisms, nevertheless their close relation cannot be doubted. We cannot go further into details of psychoanalysis, but it can be seen from the above general outline that the object to be gained is the unfolding, interpreting, and instituting of constructive methods of thought within the patient. We attempt to bring the patient to realize each symptom, its causation, and the method of logical association between cause and effect. It is obvious that psychotherapy of this sort should be undertaken only by well-trained physicians. The physician alone being conversant with diseases of the nervous system, he can form a proper judgment as to whether or not the case is suited for psychotherapy. A nonmedical "mental" healer may occasionally achieve a marvelous success in treatment, but only too often do we hear of cases of tuberculosis, Bright's disease, and many others falling into their hands with disastrous results.

CHAPTER XIV

THE RECOGNITION AND TREATMENT OF DISEASE.

RECOGNITION of the particular disease or diseases from which an individual suffers is the highest and most difficult problem of the physician. For if the final goal in every given case of sickness is to treat and cure the patient, this cannot be successfully accomplished until the exact nature of the malady is known. It is a very curious but easily explained phenomenon that this fact, so apparently axiomatic, is not fully appreciated. Most of the "isms" and "pathies" of to-day appear to ignore it; for nothing is commoner than to see certain persons or groups of persons endeavoring to treat diseases without being at all adequately cognizant of their nature or character. Many intelligent people who are accustomed to judge of the artistic, literary, and scientific capacity of individuals with whom they deal, by ordinary criteria of common sense, do not appear to require those who propose to cure them of their ills the same proof of their standing or capacity.

What is the explanation of this fact? We have already said that it is easy, but it is not entirely simple. If one wishes to have a portrait painted one goes to an artist who has painted other portraits. If one wishes to have a house built, he interviews an individual who has built houses, etc.

In each instance of this kind, examples of which could be easily multiplied, it is easy to secure concrete proof of ability. When, however, the search involves a quest for health the concrete evidence of ability to serve is not so easily obtained. Here the claim of capacity may be set up by a mountebank and the refutation of his claim is not always easy. It is possible for the quack or faker to manufacture testimonials, indeed to actually secure honest ones from dupes whom he has deceived. The *vis medicatrix naturæ*, or power of nature to cure, works as well for the quack as for the honest physician, just as the "rain raineth upon the just and the unjust"; in other words diseases in many cases tend to cure themselves and it is, therefore, not difficult for a blatant pretender in the garb of healer to obtain a reputation for skill and power to which he is absolutely unentitled. In the long run, however, his machinations and pretensions are or should be obvious to intelligent persons. It is not intended to do more in the following short résumé of the science and art of diagnosis than to show how important it is considered by the modern physician—so important as to be rightly regarded as the keystone in the hierarchy of the medical sciences. In this way the general reader will appreciate perhaps more than he ever did before the tremendous intellectual preparation which is required of every physician before he may be considered competent to practice it. The medical student of to-day must pass through a long and laborious apprenticeship, all of which preparation is intended solely to make of him a diagnostician, that is, a person who can recognize the nature of disease in particular cases. Treatment is subsidiary, for a man may learn treatment in one-

tenth the time which is required for him to learn the art of diagnosis.

The term "diagnosis" comes to us through Latin from the Greek and means to "recognize through" or "thoroughly." We speak of a science of medical diagnosis or the science of the thorough recognition of disease because we believe that in it as in every other true science, there are phenomena which occur in regular order as the effects of natural or efficient causes. It is believed that a thorough knowledge of the causes will enable us to predict the effects. In many of the sciences, as mechanics, astronomy, and physics the phenomena can be reduced to measurement in units of mass, of space and of time, but in more complex sciences, as biology, psychology, and similarly medicine, the phenomena cannot as yet be reduced to exact measurement except to a limited extent. Nevertheless it is the aim of these sciences to discover the uniformities which reside in them. It is believed that they are subject to law as rigorously as are the phenomena of physics and chemistry. To discover the laws that health phenomena and disease phenomena obey is the object of the science of medicine and to reach this goal, scientific methods must be employed.

The fundamental sciences are usually given as astronomy, physics, chemistry, biology, psychology, and sociology. As complexity increases in this series the degree to which the phenomena can be completely understood, or what Comte called the "positivity" of the science, decreases. Medicine is a branch of sociology and as sociology stands as the least positive science in the above mentioned series, it will be seen that medicine and all that is included in it is not exact.

Finally, when we consider that the science and art of diagnosis has its relations with many of the other sciences it will begin to appear how earnest and how extensive one's education must be to qualify him for the particular study of the diagnostic science and art. Of the natural sciences to which diagnosis is fundamentally related the most important are physics, chemistry, biology, psychology and sociology. It would be manifestly impossible in the brief description of the art of diagnosis to which we are perforce limited in these pages, to describe the particular relation which it bears to each of the above fundamental sciences. It will be sufficient to merely mention them, in order to understand the extent of preparatory study required by him who pretends to master the science and art of recognizing disease (diagnosis). Before the student of medicine is allowed to undertake the particular study of diagnosis in the medical school and hospital he must fit himself especially for the task. This he does by several years of intensive training in the study of all those branches which make up his medical course. Among these may be mentioned anatomy, physiology, and pathology. These topics and their correlated subjects require years of study in the medical school and hospital. Only after this long training in college, medical school, and hospital is the student fitted to undertake the perfecting of his skill in the art of diagnosis and long experience in practice may still be required to make him truly expert.

Let us consider briefly the actual process which is used by a modern physician in making a diagnosis. There are two chief stages to such a process; first an accumulation of all the data that help to localize

and define the particular morbid condition from which the patient is suffering; and second, the arranging and summarizing of the data thus accumulated, with the deductions which flow from them and which point to the particular disease present.

We shall not worry the reader with a description of the methods used by an intelligent physician to accumulate all the data presented by a given case. He is taught to follow a systematic plan. First he must record the history of the patient; second he must make a thorough physical and mental examination and record the results; third he must make or cause to be made certain necessary laboratory tests and file the results with his findings; fourth he must in many cases record the results of an X-ray examination; fifth he must in certain particularly obscure cases obtain the services of certain specialists who are qualified to make examinations of special organs or functions and record their results.

The medical history of a patient is called the anamnesis. The physician must obtain and record an account of the main complaints of the patient. He must obtain the medical history of the patient's family; his previous personal history as to illnesses, operations, injuries, occupations, etc. Finally he obtains a succinct account of the illness concerning which he has been consulted, its onset, supposed cause, symptoms, and course.

The physician by questioning elicits from the patient a full account of any or all symptoms such as pain, headache, cough, dizziness, shortness of breath, nausea, eruptions, etc., etc. Experience, tact, and common sense guide him in his development of this important part of his examination. Next comes the physical examination. Many

up-to-date physicians dictate their findings to a stenographer who records the observations as they are made. As a rule the careful physician requires his patient to be undressed and between sheets, always properly protected while the examination is conducted. In making such a physical examination the physician first makes general observations. For example, the temperature, pulse and respiration are noted. The height, weight, and general appearance are recorded. The posture, gait, and behavior are observed. The skin, glands, bones, and joints are all carefully inspected and examined. Finally the blood pressure is taken.

The physician next makes a careful regional examination. That is, he examines the head in detail, notes the condition of the skull, face, eyes, ears, nose, mouth and throat. Next the neck, its form and size. Then the chest, including an examination of the heart and lungs. Next the abdomen and finally the extremities. In examining the chest and abdomen the physician employs the methods of inspection, palpation, percussion, or tappings and auscultation or listening. With this last method he usually employs an instrument called the stethoscope.

Finally a careful examination of the nervous system is made. The patient is tested as to feeling or sensation, motor function or movement, reflex phenomena as observed in the pupils and in various situations as the elbows, knees, feet and abdomen, where certain manipulations give rise to involuntary reactions which have a definite meaning to the trained observer. Finally, a mental examination is made. The patient's memory, attention, feeling, mood, ideas and general mental state are carefully studied and all results recorded.

In making such a general and mental examination the physician uses his trained powers of observation carefully and without bias so that the results of all his observations make a harmonious whole from which valuable deductions can be made.

After the above examination is concluded the next step is to make certain laboratory tests which the physician knows are necessary to be made in every case where there is any obscurity whatever. These tests include an examination of the blood and urine and often also examination of sputum, stomach contents (obtained by tube) and feces. In special cases a much more extensive series of laboratory tests may be required, such as examination of fluid withdrawn by needle from the spinal canal or from the chest; examination of pieces of tissue taken from tumors and swellings, glands, etc.; special blood examinations, chemical and otherwise; studies of metabolism and functional capacity of organs, such as kidney and heart, etc., etc. For example, if a person suffers from high blood pressure it may be necessary to make special tests to determine the functional capacity of the kidney and heart. If a young person is suspected to be tubercular it may be necessary to perform certain skin tests to obtain a characteristic reaction (tuberculin test).

It will be readily understood by this brief *aperçu* of laboratory tests which are required in making a medical diagnosis that no one but a trained man would be able to perform them and correctly interpret the findings. Very often indeed the tests have to be performed not by the physician himself but by specially trained laboratory workers.

Next comes the X-ray examination. The use of the X-ray in the diagnosis of disease has developed

within recent years to such an extent and its reputation has been so widely circulated among intelligent people of every community that most persons are convinced of its value and of the necessity of its use in many cases. Originally it was the surgeon who made the most extensive use of the X-ray in diagnosing fractures, dislocations and injuries of the bones and joints. But nowadays the up-to-date physician makes even a more frequent use of it than the surgeon. Many physicians install X-ray apparatus in their offices and attempt to take their own pictures and interpret them. Generally speaking, however, the technical details and difficulties of the process demand the services of skilled men who devote themselves exclusively to X-ray, or as it is often called, Röntgenological work. Even after a fine X-ray picture has been taken it requires in many cases an expert to interpret it.

The commoner X-ray examinations that are made at the present day by the progressive physician to assist him with his diagnostic problems are: (1) Pictures of the sinuses or cavities about the nose to determine infection, etc.; (2) pictures of the teeth, roots and jaws to visualize unerupted teeth and latent abscesses of the roots; (3) pictures of the chest to show the lungs, the heart, and the great blood vessels, and (4) pictures of the alimentary canal, using a mixture of barium to be swallowed which casts a shadow upon the photographic plate outlining the form, size and motility of the stomach and intestines. Of course all these four sets of pictures are not considered necessary in every case, but in some particularly difficult and obscure cases they may all be required.

In addition to such routine X-ray examinations as those mentioned above it may be necessary in special cases to take other pictures. We will not attempt to mention all of the circumstances in which such a special X-ray examination would be required. Suffice it to say that if a particular region of the body is laid under suspicion by the medical examination such region ought to be examined. For example, pictures of the skull and interior of the cranium are always required in cases of suspected brain tumor; the gall bladder, urinary bladder and pelvis of the kidney must be photographed where suspicion points to stone in these localities; particular bones, joints and the spine may require a special X-ray examination.

Finally, before an obscure diagnostic problem can be solved it may become necessary for the patient to submit to special examination by men qualified in special fields. Among these may be mentioned the eye specialist, ear specialist, nose and throat specialist, the urinary specialist, the skin specialist, the nervous and mental specialist, the dental specialist, etc. No single person can hope to be equally familiar with the technical facts of all these and other specialties and consequently the physician will frequently require to avail himself of their special knowledge in the diagnosis of difficult cases.

Thus it will be seen that the mere collection of technical data required in many cases before a rational diagnosis can be made by the physician is a work requiring considerable time, patience, intelligence, industry, sympathy and knowledge which cannot be expected to be found in any but a highly educated and well trained individual. How can intelligent persons expect quackery and dilettantism to

supply that which only time, opportunity and training can supply?

We must not weary the patient reader by attempting to explain the actual processes of ratiocination or logical thinking by which the physician deduces and induces from his data the great object of his search—the diagnosis. Suffice it to say that after all the data have been accumulated they are arranged and summarized and the physician must then ponder thoughtfully upon all the implications which may flow from his array of facts. All likely hypotheses are taken up and debated, each one being compared with all the facts and it is not until a hypothesis has been found which accords with all the facts that the solution of the problem is at hand. Several possible hypotheses always present themselves and these are pitted against each other, as rivals in a tournament, all fighting for supremacy. The doubts that may arise in such a mental combat sometimes force the physician to make even further examinations of his patient, to accumulate more data in other words, which will finally allow the one certain hypothesis rather than another to be accepted as embodying the diagnosis of the case. This is never done, however, until each hypothesis has been patiently and impartially considered, each diagnostic suggestion or inference debated and critically analyzed.

It was well said by that great American physician and master of the science and art of diagnosis, Barker, that “the natural capacity, the experience, and the ideals of the diagnostician will have their influences upon the work that he does. They will reveal themselves in the practical technique of fact accumulation, in creative imagination, in reasoning power,

in verification, in philosophic grasp and in esthetic appreciation." What Faraday said of the philosopher is very applicable to the diagnostician of the higher type. "He should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature."

Thus we may end our brief consideration of the subject of medical diagnosis, hoping merely to have given sufficient insight into its mysteries, its difficulties and its importance to impress the reader with the futility of expecting results in this difficult field by any short cut substitutions for the real article of merit. Diagnosis is the sublime pinnacle in the edifice of the medical sciences and those who choose to sacrifice themselves as votaries of the medical art must purge themselves of egoism before they may enter the inner temple. There is no royal road to the mastery of diagnostic science or art. Let that man be justly suspected who pretends to be its master and who has not served apprenticeship.

TESTS OF VITAL FUNCTION

In medical diagnosis at the present day much use is made of methods which have been especially developed in very recent years and which are comprised under the general heading of Tests of Vital Function; or Vital Function Testing. The development of these methods has been a large factor in giving to the medicine of to-day its strongly func-

tional trend. The object of diagnosis is primarily to discover what organ or organs are affected and the particular nature of the disease process. But beyond this, in recent years it has come to be appreciated that what we desire most to know in a given case, is the degree or extent to which the affected organ has become functionally disabled by reason of the disease. For example a man has Bright's disease and the urine contains albumin and casts; as long as our knowledge stops here we are considerably handicapped in forming any adequate notion of just how sick the individual is. It is not until we have been able to estimate just how much functional capacity is left in the kidney, just how much work this organ is still able to do, that we can form any just idea in this regard. What is true of the kidney is true of the heart, the liver, and other vital organs. It is not to be wondered at that physicians have interested themselves so much in the development of tests which will enable them to measure the functional capacity of organs and that during recent years many tests have been perfected.

It will be impossible within our limits of space to give anything more than a general idea of this important and fascinating medical subject. That the reader may get some idea of the subject, however, we will briefly describe some of the methods which are in use for determining the functional capacity of the kidney.

The kidney functionally is almost a purely excretory organ. It rids the body of certain ashlike substances which represent the end products of bodily combustion or metabolism. Examination of its product, urine, therefore, has always constituted a precious means of estimating the state of the

kidney. Urinalysis is a very complex subject and the results obtained are always carefully pondered by the physician. But no urinalysis, however complete, gives an adequate comprehension of the actual functional capacity of the organ. A specimen of urine may contain albumin, which is a pathological (disease) product, and yet such a specimen of urine may come from a kidney in better functional condition than one which is secreting urine absolutely free from albumin. Even functional tests do not enable the physicians to predict with certainty what the kidney looks like and physicians are continually surprised at the appearance of this organ post mortem after the most complete chemical and functional examinations have been carried out during the life of the patient.

One especially good test of kidney function is the so-called red test of Rowntree and Geraghty. It is based upon a study of the rate of excretion of a red dye known by the long chemical name of phenolsulphonphthalein. This is a nonpoisonous dye which can be injected into the body and is excreted by the kidney in the urine. The color can be brought out in the urine by addition of alkali and the amount of dye estimated with a proper color scale. This test has been found very useful both in medicine and surgery and is frequently made use of.

Another measure of the efficiency of the kidneys can be made by testing the ability of these organs to excrete water and solids under conditions where the amount of fluid and solid intake and output is rigidly controlled and measured. The normal kidney responds quickly, like every other normal organ, to extra demands upon its capacity to work. If a considerable amount of fluid is given, the urine

quickly increases. If solid foods are increased the amount of urine diminishes. Under normal conditions of kidney function, on an average diet, the bulk of urine (two-thirds) is excreted in the day. Usually only a third is excreted at night. These facts serve as a very useful test of renal function known as the intake-output test, or commonly in this country as Mosenthal's test, from an American physician who elaborated and popularized it.

It will be impossible to describe any of the tests which are used for examining the functional capacity of other vital organs. Only enough is given to acquaint the reader with the existence of such tests and emphasize their great importance.

TREATMENT

We now come to the final aim of all medical science—the treatment of disease. How inadequate must be our description of it! The reader who has conned the pages of this volume up to this point will understand that it cannot be our intention to give any details concerning the actual treatment of diseases. Volumes are written upon it. It is a question constantly changing, shifting, developing, so much so that even the earnest physician can scarcely keep pace. Hippocrates summed it up when he said, "Life is short and the art long, the occasion fleeting, experience fallacious and judgment difficult. The physician must not only be prepared to do what is right himself, but also make the patient, the attendants and externals cooperate."

The Father of Medicine probably referred in this his first and immortal aphorism to the subjects of diagnosis and treatment. He recognized their great complexity. In other portions of his writings he

recognized the importance of scientific methods in the development of medicine.

The treatment of disease in every age has varied with the conceptions of the nature of disease prevalent at the time. Osler says that there have been three great conceptions of the nature of disease, hence three great conceptions of treatment. First, for long centuries disease was regarded as the direct outcome of sin, "*flagellum Dei pro peccatis mundi*"—the castigation of the Almighty for the sins of the world (Cotton Mather). Secondly, after Hippocrates until the time of John Hunter many doctrines of disease fought with one another for supremacy. These have been briefly described in the first or historical portion of this volume. During this long period when diseases were believed to be due to peccant humors treatment consisted of purging, bleeding and sweating.

Thirdly, during the past half century our conceptions of the nature of disease have undergone a revolution. The real causes of many diseases have been worked out. No longer is the entire aim to cure, but to prevent disease. Fearful scourges have been abolished. Treatment has become more stabilized, more rational, more scientific, hence more effective.

Rowntree has codified our present day therapy or treatment of disease into six categories, namely, Rational Therapy, Empirical Therapy, Baseless Therapy, Diagnostic Therapy, Supernatural Therapy, and Preventive Therapy. Of course, the first and last are the best because they are founded upon reason and science.

Drugs have come down to us from antiquity, but it is only in the last half century that the true

science of the action and uses of drugs or pharmacology was born. A great deal is now known of the chemical nature of drugs, and something at least can be predicted of the action of a drug by a knowledge of its chemical composition.

The use of quinine in malaria, salicylates in rheumatism, nitrites in arterial spasm, morphine in pain, antipyretics in fever, may be cited as a few examples among many others that could be mentioned of the wise, rational, and effective use of drugs in the treatment of disease. Physicians use fewer drugs than formerly and understand them better.

In recent years specific chemical substances have been developed and their action studied experimentally in diseases artificially created in animals. When a thorough knowledge of their action had been learned in this way they were transferred in certain cases to human therapy. African sleeping sickness was the disease in which this new departure in so-called chemotherapy was first developed. This field of science was created almost entirely by Paul Ehrlich and culminated in the introduction of Salvarsan or 606—one of the great specifics of the day and a boon to humanity.

The discovery by Pasteur of microorganisms (germs) as the cause of disease also revolutionized many of the principles and much of the practice of therapy. In the first and second chapters of the second part of this book this subject has been sufficiently developed. There the use of serums and vaccines in the treatment and prevention of diseases has been described.

Lister's application of Pasteur's ideas of sepsis and antisepsis revolutionized surgery. With the advent of the World War came the need for developing the

subject of antiseptic surgery. The problem was attacked by Carrel and Dakin and led to the utilization of substances nonirritating to the tissues and yet of sufficient germicidal power to kill all microbes of all varieties present in wounds. These pioneers developed the so-called Carrel-Dakin solutions—solutions of chlorinated soda, chloramine-T and dichloramine-T. These solutions in proper concentrations were used by continuous irrigations in infected wounds and abundant proof soon accrued as to their value.

Within very recent times another great field of therapy (treatment) has been explored, namely, the use of the internal secretions or secretions of ductless glands. In another part of this work these glands have been discussed. The secretion of the thyroid gland may be mentioned as a splendid example of a secretion formed within the body and which may be employed under certain circumstances as a drug of potent power.

The application of the principles of nutrition, of metabolism, of dietetics, to the treatment of disease must here be referred to because of their great importance. More study is being given at the present day to problems of nutrition and metabolism than to any other domain of medicine and rightly so, for when their problems shall be solved many riddles of our day will lie like open books before us. Even that greatest of all medical problems, cancer, comes within this category.

The functional conceptions of disease which rule our present day pathology are playing a great part in the treatment of many diseases. In the special domains of therapy of the heart, kidney, liver, nervous system; in fact, all organs of the body, a

better appreciation of function has brought about a more rational application of the principles of treatment to various diseases. Obviously we cannot dwell upon the special treatment of particular diseases or of special organs. But the modern application of digitalis to diseases of the heart may be mentioned as a notable example.

Hydrotherapy or treatment by water and baths is a very ancient method, but only comparatively recently has it been constituted a science. The exact effects of hot baths and cold baths are now known and the special treatment of fevers, heart and kidney diseases, obesity, rheumatism, insanity, etc., by special types of hydrotherapy now constitute important and effective means of combating disease.

The properly equipped social worker has come to occupy her proper place not only in the diagnosis but in the treatment of disease.

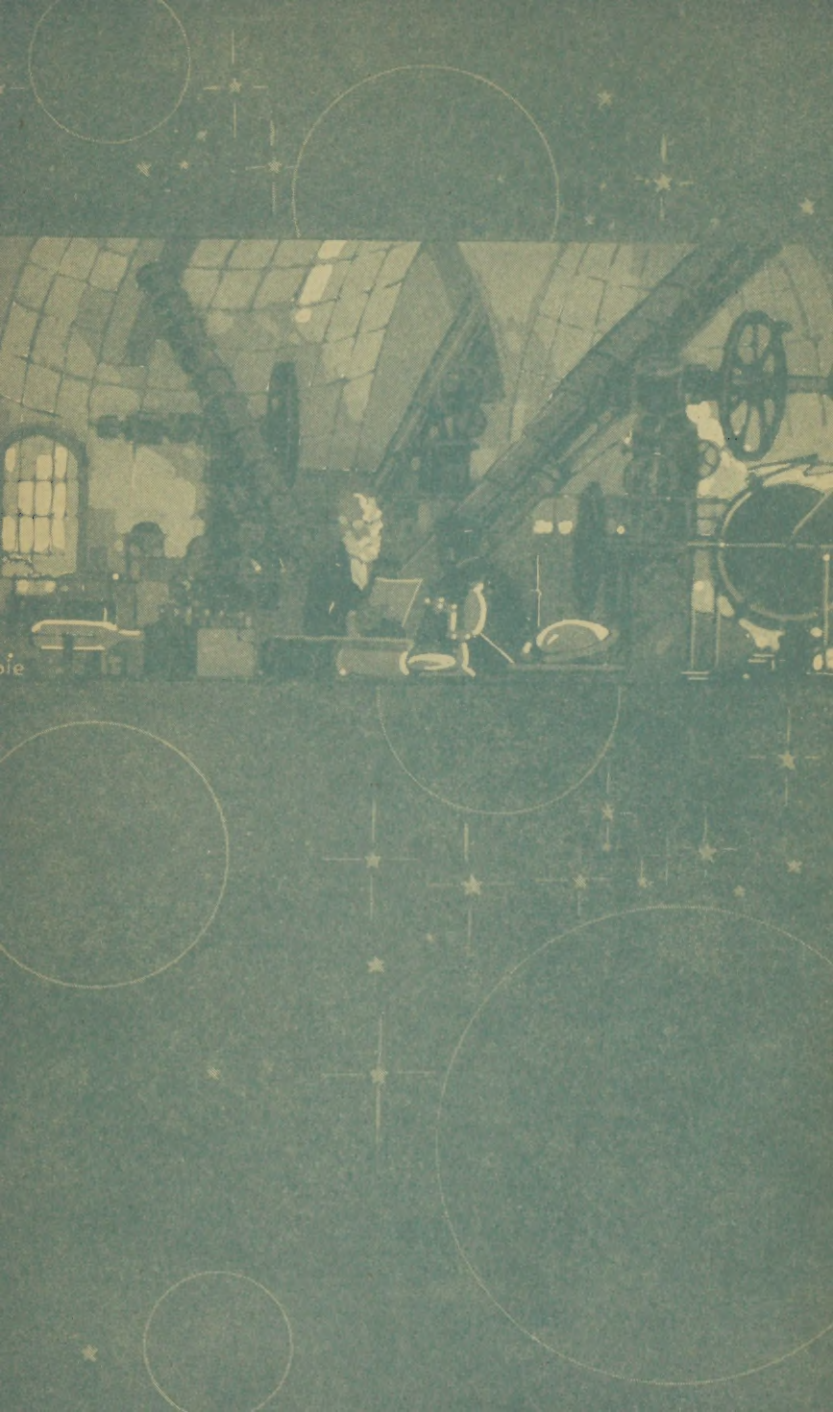
Climatology has now become a science and the effects of temperature, of altitude, of moisture, of air movements and other phases of climate are better understood. Hence the knowledge of actual climates adapted for sufferers from tuberculosis, heart, kidney and nervous diseases has become an integral part of the armamentarium of the modern physician.

Finally the actions of radiations, including radium and the X-ray, have come to be understood and the use of radiation in therapeutics (treatment) has been placed upon a scientific foundation.

Methods have been devised for exact dosage and control of these potent and mysterious agencies. The most striking and widespread use of radiation in therapy is in the treatment of cancer and other tumors, some forms of which quickly melt away before the radiations. In spite, however, of the

remarkably gratifying effect produced at times in entirely curing the disease, radiotherapy, as this treatment is called, has not reached such a sure stage in this connection that it is used in preference to operation where this is possible. This use of radiation in localized tubercular disease can only be mentioned. During the recent war radiotherapy found almost sensationally interesting applications. Aside from its use in the types of diseases met with in civil practice it was used in the treatment of septic wounds, and especially to prevent disfiguring scars after extensive operation of plastic, i. e., reparative, surgery. Other uses too numerous to mention were established. Bovie in an interesting article states, "As our knowledge concerning the relation between the organisms and this imponderable part of their environment increases radiation will find a place in treatment as secure as that now held by chemicals in rational scientific medicine."

We may profitably close our brief and somewhat discursive reference to treatment by quoting the words of Rowntree: "Since doctrines control therapy, treatment will improve as medicine advances. This involves the adaptation to medicine of all that is applicable in science. All progress in the fundamental branches eventually advances practice; the healing art must give place to the healing science."





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